FORESTRY RESEARCH HIGHLIGHTS 1969

ROCKY MOUNTAIN
FOREST AND RANGE
EXPERIMENT STATION
Forest Service
U. S. Department of Agriculture

OFFICES AND LABORATORIES OF THE ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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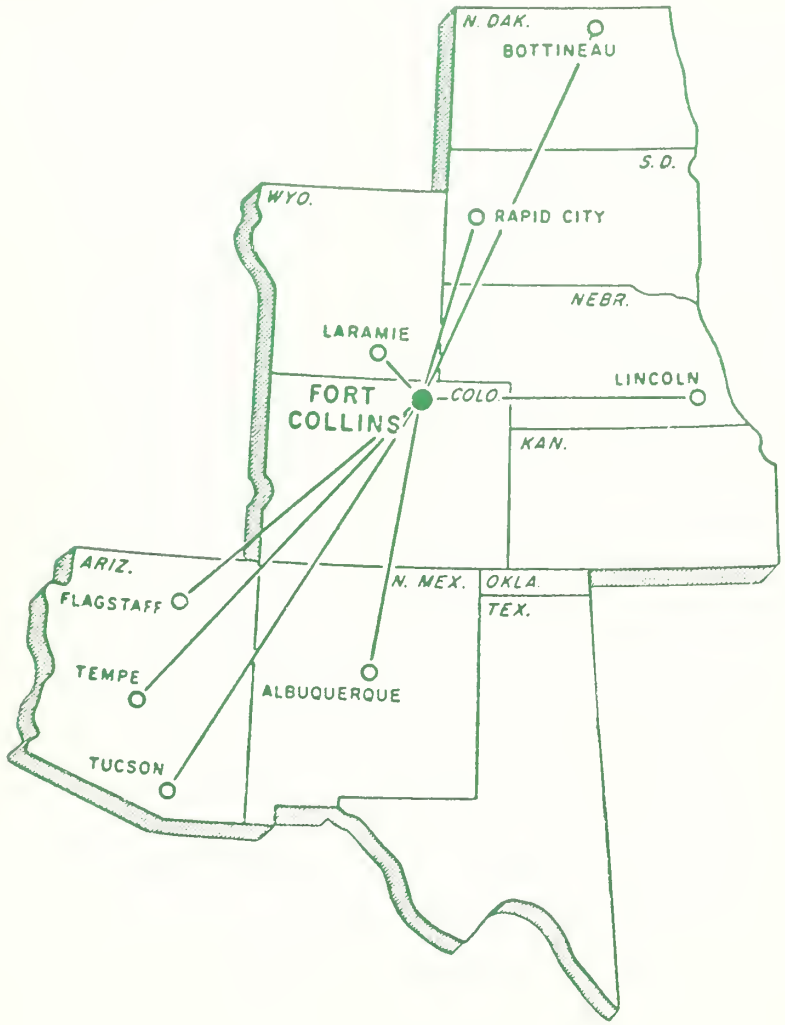


FORESTRY RESEARCH HIGHLIGHTS

1969

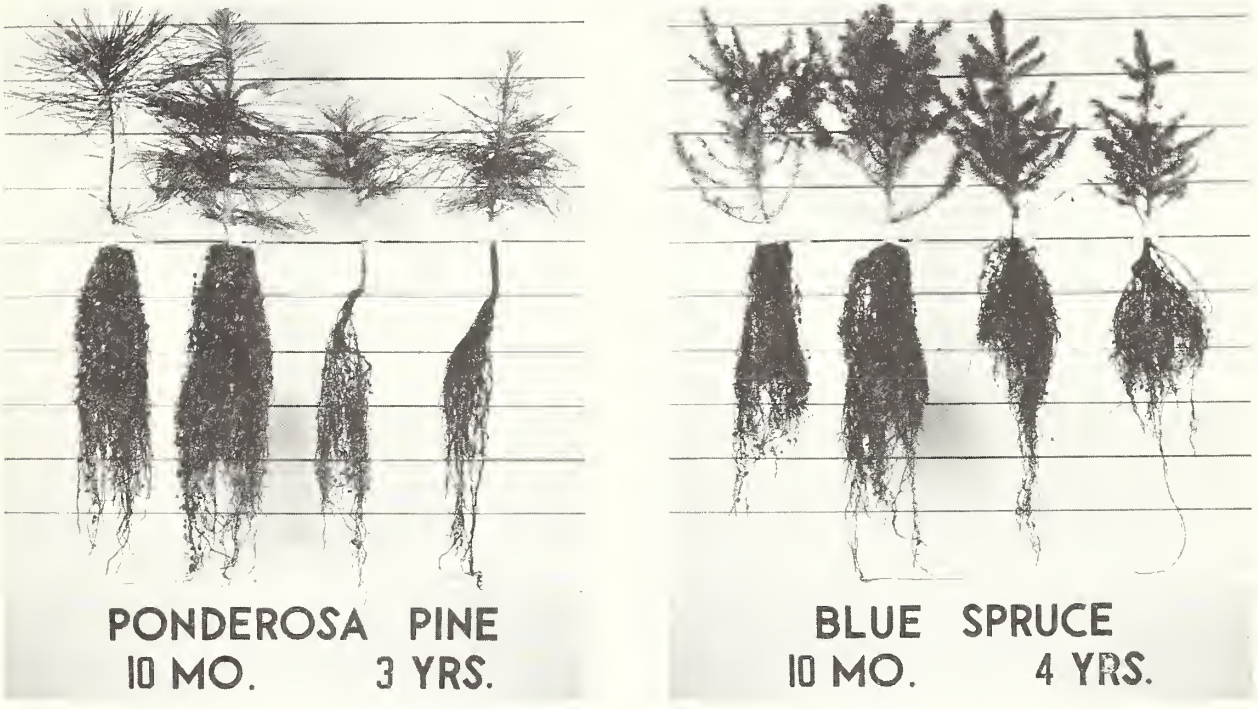
ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

CONTENTS

SOME BREAKTHROUGHS

SEEDLING PRODUCTION TIME REDUCED BY TWO-THIRDS

Ponderosa pine and blue spruce planting stock grown in a specialized greenhouse in less than 1 year proved superior to 3- or 4-year-old nursery stock of the same species. This finding comes from an experiment being conducted by Dr. Richard W. Tinus, plant physiologist at our Bottineau, North Dakota, research center.



The two trees on the left in each photograph were greenhouse grown for 10 months. The two ponderosa pine and blue spruce on the right were nursery grown for 3 and 4 years, respectively.

Dr. Tinus reports that the rapid seedling production is made possible by the 12-month controlled growing season provided by the greenhouse environment. "In the greenhouse," he explains, "we can accurately control daylength, water, fertilizer, temperature, and air. Incandescent lights provided the long days needed to keep the seedlings growing; we found that illumination for 1 minute out of every 30 minutes throughout the night is as effective as continuous light for preventing dormancy in ponderosa pine. Air control is another important part of the operation. By filtering the air, we keep the interior free of insects and weed seeds which might cause trouble, and we increase the carbon dioxide level which makes the seedling growth process more efficient."

The experimental trees are seeded in pots that need not be removed before transplanting, thus eliminating root injury and minimizing the damage of field planting. The synthetic potting material used weighs much less than soil and allows better root development.

Other advantages of greenhouse culture pointed out by Dr. Tinus include (1) improved trees, as they are developed, can be grown and placed in use in about one-third the time presently needed; (2) greenhouse tree production is very adaptable to automation and year-round operation; and (3) the greenhouse is independent of climatic and soil conditions and can thus be located so as to serve its customers most economically and efficiently.

Although his greenhouse experiments offer an exciting potential, Dr. Tinus is quick to recognize some limitations of the method. The cost of greenhouse tree culture is unknown, and it is likely to be higher than that of current nursery methods. It must be remembered, however, that the greenhouse will produce a higher quality and thus a higher value tree product. Optimum greenhouse environments will need to be determined for each desired tree species just as they have been determined for a wide variety of floral and vegetable crops. Finally, potted stock is bulky, heavy, and more difficult to ship than nursery stock. No problems are envisioned with present

machine planting methods.

Future studies are planned which will further investigate the pros and cons of greenhouse seedling production.

FOREST MANAGEMENT COMPUTERIZED

It seems that computers can help with just about any job including recordkeeping and decisionmaking for forest management. These electronic wizards have proven invaluable in many phases of business and government, but they have been little used in natural resource management.

Dr. Clifford A. Myers, Jr., principal mensurationist, has developed three computer programs which can help forest managers make decisions for managed even-aged forests.

First, he has developed a program that will compute and print yield tables for numerous combinations of site quality, thinning frequency and intensity, and other variables. Research Paper RM-43, authored by Dr. Myers, discusses this program.

Second, changes in the forest or in its economic surroundings can be simulated so as to select management goals and prescribe methods for achieving those goals. For example, forest changes caused by growth, harvesting, and fire, combined with timber production in terms of volume, dollars, and interest may be simulated before selecting thinning and harvesting intervals. This simulation is described in Research Paper RM-42.

Third, the computer can prepare and print a complete management plan using forest inventory data and information from the other computer programs.

Dr. Myers emphasizes that his computer forest management system makes it relatively easy to consider a very broad range of information before planning decisions are made. Also, the system makes possible much more intensive and responsive forest management because management plans can be updated annually, or more frequently, if needed. Up to now, forest management plans have seldom been made for less than a 10-year period because their preparation was such a long, laborious task.

A rigorous field test of the procedures is being planned to insure that the computerized forest management system is as practical and helpful as possible. Dr. Myers plans to gather pertinent data for a 2-year period from an entire National Forest. Using this information, he will analyze planning problems presented by forest managers.

At present, the computer programs deal only with timber management because the mathematical relationships needed were available for some Rocky Mountain tree species. According to Dr. Myers, "It is possible, however, to include other resources as information becomes available. For example, soil factors that help predict tree growth can also be used to estimate forage production. Non-numerical analysis is also a possibility; forests being evaluated for timber production could also be described and rated by their esthetic appeal and recreational potential."

PHOTOGRAPHY HELPS UPDATE RANGE INVENTORY

Dr. Richard S. Driscoll, Project Leader for our range inventory and analysis studies at Fort Collins, is using space photography, aerial photography, and microdensitometry to update range inventory techniques.

Space photographs provide a basis from which an initial, general classification of vegetative types can be made. Aerial photographs are used to determine the areal extent and general composition of specific vegetative types. Once specific image characteristics have been well defined by photointerpreters, a microdensitometer can be used for automated interpretation and analysis.

Dr. Driscoll used color infrared space photography from the Apollo 9 Mission to identify and delineate five vegetative types in the Roswell, New Mexico, area. The photo scale (1:2.8 million) and the ground resolution (about 250 feet) permitted only a very broad classification. This work was done in cooperation with the Earth Resources Survey Program of the National Aeronautics and Space Administration.

Color infrared aerial photographs at scales of 1:80,000, 1:20,000, and 1:2,400 were used to gain more specific information about the areas identified on the space photographs. The 1:80,000 photos were satisfactory to determine the areal extent of vegetative types with strongly contrasting images. The 1:20,000 photos made possible better identification of vegetative types with subtle image differences. Photos at a scale of 1:2,400 provided the needed detail for determining the density (numbers) and identity of individual shrubs that were spaced more than 3 feet apart.

Photos at scales from 1:800 to 1:1,000 were needed to identify individual shrub plants that were closely spaced with their tops nearly touching.

A photointerpretation test compared film types, photo scales, and season of photography for the identification of 11 shrub species from a Colorado test site. In general, color infrared photos obtained in June at a scale of 1:800 to 1:1,000 provided the best information. Specific results were:

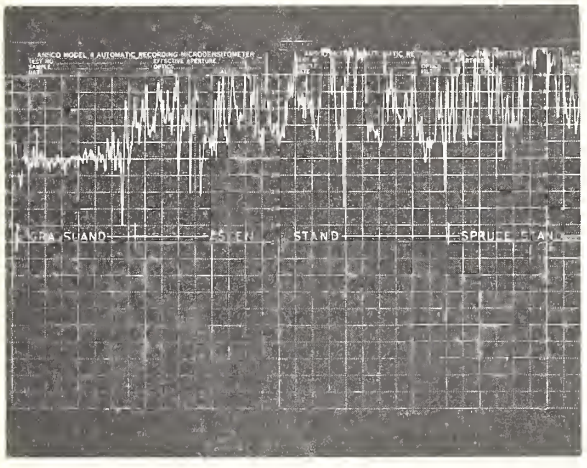
1. Identification of individual shrubs was significantly better, regardless of interpreter experience or shrub species, when color infrared photos were used rather than

regular color photos.

2. Interpreters differed significantly in their ability to identify shrub species from photos. Photointerpretation experience and knowledge of the area photographed were important factors. The most experienced interpreter correctly identified all 11 shrubs with more than 90 percent accuracy. The least experienced interpreter identified 6 of the 11 shrubs with more than 80 percent accuracy.
3. Identification of some species was significantly greater regardless of film type or interpreter. This was a result of plant size and film resolution.

A scanning microdensitometer can be used for automated interpretation after the photo-image characteristics for particular plant communities or species have been accurately defined by photo-interpreters. The automated system, combined with a computer, will provide direct quantitative analysis of the photo information.

The microdensitometer, with an attached strip chart recorder, can provide a graph of the optical film image density along a predetermined scan line.



The scan line produced by a microdensitometer as it crossed a color infrared transparency. Notice that there was a sudden change in relative density between the grassland and aspen forest, while the change from aspen to spruce forests was more subtle. Low density readings in the forests are logs on the ground or individual tree trunks. High density readings are tree crown shadows.

It was possible to discriminate among native grassland, seeded grassland, deciduous forest, and unharvested and harvested coniferous forest, using small-scale (1:135,000) color infrared transparencies and the microdensitometer. The image density of bare soil was significantly less than that of any other film image.

Identification of individual shrub species with the microdensitometer was best with large-scale (1:600 to 1:1,500) color infrared aerial transparencies. However, no one photography date enabled consistent discrimination. For example, image density ranges of alkali sagebrush and big sagebrush were very similar on August photographs, while the image density of bitterbrush was noticeably higher. If the objective is to separate the two sagebrush species, August photography is not satisfactory. However, August photography is fine for general discrimination between bitterbrush and sagebrush.

TREES HELP SOLVE TRAFFIC NOISE PROBLEMS

During the last 30 years, the average community sound level has increased eightfold. A University of Nebraska study, in which we are cooperating, is determining the effectiveness of trees and shrubs in controlling noise, especially in urban and recreation areas. It has been found that noise, or unwanted sound, can be reduced up to 50 percent by appropriate barriers of trees and shrubs.

High-capacity sound equipment is used to project tape-recorded traffic noises through tree barriers of varying compositions. The various pieces (from left) are a sound data recorder, tape recorder and playback unit, sound projection cabinet with top-mounted high-frequency horn, weather instruments, sound-level meter, audio amplifier, tripod-mounted microphone, and portable power supply.

Professor David Cook of the Department of Engineering Mechanics at the University of Nebraska directs the project. Dr. David Van Haverbeke of our Lincoln research center is cooperating in the 3-year project.

Extensive field experiments were conducted in 1969 and are being continued in 1970. Pro-

fessor Cook explained the procedure as follows: Tape-recorded traffic noises are projected through belts of trees and shrubs of varying composition with a high-capacity sound system. The sound level is then measured at varying distances behind the belts of foliage. The procedure is then repeated at a nearby location where no trees or shrubs are present. A comparison of the measured sounds, with and without the intervening foliage, gives an indication of the effectiveness trees and shrubs have in reducing sound levels.

Tree barriers consisting of all evergreen trees, of all deciduous trees, and of mixed evergreen-deciduous compositions will be tested. Variations in sound levels caused by the heights and widths of these barriers will also be studied.

When the project is complete, Professor Cook and Dr. Van Haverbeke will make their findings available to landscape architects and others who design plantings adjacent to urban and recreational areas where high noise levels are objectionable.

A NEW CLASSIFICATION FOR SNOW DEVELOPED

Dr. Richard A. Sommerfeld, associate geologist with our Fort Collins alpine snow and avalanche project, has developed a new snow classification in cooperation with Dr. E. R. LaChapelle of the Wasatch National Forest in Utah. The classification makes it possible to describe the various snow layers according to the type and extent of change the snow has undergone.

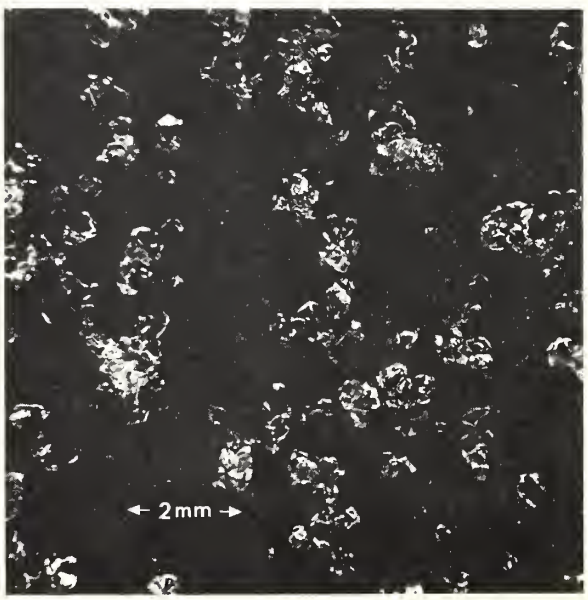
Classifications of snow in the air are of little help when describing snow on the ground, since the snowpack undergoes constant change. According to Dr. Sommerfeld, changes in the size and shape of grains and the degree of bonding between grains are caused by (1) the redistribution of water vapor with and without temperature gradients, (2) melting and refreezing, and (3) compression.

Grains transformed in the absence of a strong temperature gradient are rounded and have few flat surfaces. This process of vapor transport from small grains and sharp angles to larger grains and rounded surfaces leads to a decrease in the number of grains and an increase in their average size.

Grains formed in the presence of a strong temperature gradient are angular with flat faces and stepped surfaces. This process of sublimation of water vapor from the tops of grains and deposition on the bottom of grains above also leads to a decrease in the number of grains and an increase in their average size.

Dr. Sommerfeld's snow classification has been published and is available as Research Paper RM-48. The reader is also referred to the **Journal of Glaciology** (No. 55, 1970) for "The Classification of Snow Metamorphism" by Sommerfeld and LaChapelle.

Snow grains formed in the presence of a strong temperature gradient are angular with flat faces and stepped surfaces.



Snow grains transformed in the absence of a strong temperature gradient are rounded and have few flat surfaces. No evidence of the original grain shape remains.

UNDERSTANDING THE FOREST AND RANGE ENVIRONMENT

FOREST INFLUENCES

GREAT PLAINS TREE IMPROVEMENT PROGRAM PROGRESSING

Nebraska plantations, such as the one shown here, represent a wide range of origin for each of 11 tree species. These plantations provide (1) a test of the trees' adaptability to the Great Plains environment and (2) genetic material for tree selection and breeding. The older plantations are beginning to produce cones and pollen that will be used to select and breed improved tree stock for the Great Plains.

Austrian pine and Scots pine are in the foreground of this Nebraska plantation. Other species present include Japanese larch, northern red oak, red pine, limber pine, jack pine, eastern cottonwood, Douglas-fir, ponderosa pine, and eastern white pine.

The broad geographic range of trees within one species is illustrated by Scots pine. Test trees of this species are the progeny of trees in a range from central Spain northward to Sweden and Finland and eastward to Greece, Turkey, and Siberia. This broad range increases the opportunity to select trees with greater resistance to heat, drought, cold, diseases, and insects.

This wealth of genetic materials for tree improvement research in the Great Plains was made possible through a regional project of the North Central States Agricultural Experiment Stations with which the Forest Service cooperates. Since 1960, seeds have been obtained and the seedlings produced by one of the State initiating cooperators. Planting stock is then shipped to all cooperating States that want to test the particular species.

This Scots pine is from central Czechoslovakia. It was 13 feet tall after 8 years in the field.

Twenty clones of poplar hybrids are being evaluated to find better, fast-growing broadleaf trees for shelterbelt plantings. The tallest trees in this photo are hybrids of eastern cottonwood and the Volga cultivar of Eurasian black poplar. They were 50 feet tall after 9 years in the field.

A

This southern Black Hills park was nearly treeless in 1924 (A). The same area supported many ponderosa pines in 1968 (B). The man in the 1924 photo was preparing the hole for the fencepost in the center of the 1968 photo.

PINES ARE TAKING OVER SOUTHERN BLACK HILLS PARKS

There has been much speculation about the origin, status, and permanence of the many small upland parks which are interspersed through the ponderosa pine forests of the southern Black Hills. Were these grassy islands once forested like their surroundings? Will they remain grasslands?

The accompanying photographs of the same southern Black Hills park taken in 1924 and 1968 show an unmistakable trend: the pines are taking over and the parks are losing their identity.

Irregularities in size and distribution of the trees now present suggest that the pine invasion has been sporadic but steady. Although the parks have been showered over the years by vast numbers of windblown pine seeds, only a small fraction have produced firmly established trees. The earliest trees probably owe their existence to the accidental landing of seeds in spots not occupied or strongly influenced by competitive plants during years of especially favorable moisture. A few such trees were already present in the park when the 1924 photo was taken. As these scattered pioneers developed, they evidently brought about the establishment of more trees by providing additional seed sources within the park and by reducing the vigor and density of nearby ground cover.

Why has the pine invasion proceeded at a relatively fast pace during the past 40 years in parks that appear to be much older? Fire protection and grazing are probably key factors. Prior to settlement, these parks were undoubtedly burned by fairly frequent wildfires which killed most of the invading pines while they were yet small. Also, regular grazing and trampling of the parks by domestic stock has probably made the protective mantle of ground cover less resistant to pine establishment.

B

RANGES

FERTILIZERS REDUCE PULL-UP OF SHERMAN BIG BLUEGRASS

Sherman big bluegrass is an excellent, high quality forage producer in the Rocky Mountain region. Unfortunately, its root system is relatively weak and many plants are pulled up by grazing animals. Recent tests indicate that pull-up may be substantially reduced by nitrogen (N) or nitrogen and phosphorus (P) fertilizers.

Fertilizers were applied at the rate of 50 pounds per acre elemental N and P. In greenhouse experiments, application of N alone increased the tension required to pull plants by 20 percent. Under field conditions, tension to pull plants was increased most (33 percent) through the addition of both N and P. The compound fertilizer also increased foliage weight by 14 percent and root weight by 30 percent.

Tensions measured by a dynamometer showed that rooting strength of Sherman big bluegrass was greatly increased by an application of nitrogen and phosphorus fertilizer.

CAPACITANCE METERS USEFUL FOR ESTIMATING SHRUB PRODUCTION

Electronic capacitance meters are providing a rapid, accurate, and nondestructive means of estimating shrub production with a considerable reduction in cost. Excellent correlation between meter readings and measurements of current growth, old growth, and total plant weight were obtained for big sagebrush in Wyoming, winterfat in Utah, and fourwing saltbush in California.

Tests are being conducted in cooperation with the Pacific Southwest Forest and Range Experiment Station.

STEERS GAIN WELL WITH AND WITHOUT FORBS

Steers gained equally well with and without forbs as a part of their diets on ranges in the Big Horn Mountains of Wyoming. Forbs were removed with herbicides from ranges which normally have a grass-forb mixture. The steers' diet was about 42 percent forbs throughout the summer on unsprayed areas. In contrast, the forb content of the diet on sprayed areas declined from 33 percent in mid-July after spraying to 14 percent by late August. Diets were determined from rumen samples pumped from live animals.

SHEEP FORAGE HAS WIDE RANGE OF DIGESTIBILITY

At the time of maximum standing crop, 54 species of Wyoming alpine plants eaten by sheep ranged in digestibility from 35 to 78 percent. The forage species most abundant in sheep diets were those of intermediate digestibility: red fescue, American bistort, bluegrasses, dwarf clover, golden avens, and **Carex elynoides.** Spike-fescue was the most digestible of the species tested.

PLANT-SOIL CHARACTERISTICS OF ALPINE RANGES STUDIED

Analyses of vegetational, soil, and environmental factors at 29 timberline areas in the Medicine Bow Mountains, Wyoming, showed great diversity in the ecological behavior of plant species. Two intergrading plant communities, the Geum turf and Deschampsia meadow, formed an overall vegetation continuum.

The Geum turf community tended to occur at high elevations on coarse-textured soils of high organic matter.

In contrast, the Deschampsia meadow occurred at lower elevations on finer textured soils of lower organic matter content. The pH averaged 4.9 and was remarkably constant throughout the profile. Variations within the Deschampsia meadow community appeared to be associated with the depth of winter snow. Alpine fleabane, false strawberry, and **Juncus drummondii** were associated with deep snow. Tufted hairgrass and upright forbs were associated with more shallow snow accumulations.

SNEEZEWEED REDUCED BY GOPHER CONTROL AND LIGHT GRAZING

Orange sneezeweed production was substantially reduced over a 5-year period on Grand Mesa in western Colorado by a combination of pocket gopher control and light grazing. This noxious weed, relatively common on western mountain rangelands, is poisonous to sheep and unpalatable to cattle.

Sneezeweed production, over the 5-year period, (1) declined 81 pounds per acre where gophers were controlled and livestock was excluded; (2) declined 49 and 32 pounds per acre, respectively, with and without gopher control under light to moderate grazing; (3) increased 18 pounds per acre on heavily grazed range where gophers were not controlled; (4) declined 4 pounds per acre on heavily grazed range where gophers were controlled; and (5) declined 29 pounds per acre where cattle were excluded and gophers were not controlled.

LEHMANN LOVEGRASS CAN GROW UNDER VELVET MESQUITE

Lehmann lovegrass produces relatively high herbage yields under velvet mesquite that severely limits production of native perennial grasses. Lovegrass was seeded from the air on undisturbed soil in 1954, on a part of the Santa Rita Experimental Range near Tucson, Arizona. It increased slowly at first, but since 1964 lovegrass production has exceeded 600 pounds per acre and has made up 75 to 80 percent of the total

A

B

Orange sneezeweed (A) nearly disappeared from this range on Grand Mesa in western Colorado after gophers were controlled and cattle were excluded (B).

perennial grass production. The native perennial grasses are still producing as much as they did in 1954 and 1955, but they did not respond to good summer rainfall in 1964 and 1966 as they did in 1958 and 1959, before lovegrass became dominant.

CATTLE WEIGHT GAINS HIGH ON CONVERTED CHAPARRAL RANGES

Cattle weight gain on chaparral ranges which had been converted to weeping lovegrass was 81.4 pounds per acre while animals grazing native chaparral gained only 9.4 pounds per acre. Individual cattle grazing weeping lovegrass averaged 257 pounds gain during the year, while those grazing native chaparral gained only 167 pounds.

BUFFELGRASS IN "INTERMEDIATE" PITS IMPROVES SEMIDESERT RANGES

Buffelgrass, introduced from India, produced up to 2,300 pounds of herbage per acre when seeded in pits. Grass production on unimproved native range varied from 0 to 150 pounds per acre. These tests were made in cooperation with the U. S. Soil Conservation Service on southern Arizona sites which receive approximately 10 inches annual rainfall.

Buffelgrass was planted before the summer rains, at the time the pits were made. "Intermediate" pits are about 5 feet wide, 7 feet long, and 6 inches deep. The seeds of annual grasses and forbs that would compete with the planted species were scraped away, and basins were formed for the accumulation of rainwater. The depth of wetting in these pits was more than twice that on adjacent unpitted soil.

SPRING GROWTH IMPORTANT FOR ARIZONA COTTONTOP

Winter-spring grazing has a greater impact on Arizona cottontop than was formerly believed, because summer production of this valuable native perennial grass is determined by spring growth. New culms, which lead to tuft diameter increases, originate from buds that break dormancy during the spring. The plants produce few if any new stems during the summer rainy season when most foliage growth occurs. Studies at the Santa Rita Experimental Range in southern Arizona show that stems and roots of Arizona cottontop are long-lived, that soil moisture at any time during the warm season quickly produces vegetative growth, and that viable seed can be produced under good growing conditions at any time from early spring to late fall.

MESQUITE SEED VIABLE AFTER 20 YEARS

New mesquite seedlings may be expected for several years after a range is cleared, even if no new seeds are produced or brought into the area.

About 90 percent of the 450 mesquite seeds buried in glass jars at the Santa Rita Experimental Range sprouted or decayed within 10 years. One velvet mesquite seed, however, was viable when recovered 20 years later.

A

B

(A) Untreated range with little but burroweed and annual grasses. (B) Intermediate-pitted area with buffelgrass planted in 1963. Both photos were taken in April 1969.

WILDLIFE HABITAT

DEER HABITAT IS IMPROVED BY THINNING PONDEROSA PINE IN THE BLACK HILLS

Thinning immature ponderosa pine stands in the Black Hills increased total understory vegetation. Grasses and sedges increased, but there was little if any increase in total shrub, legume, or forb cover when stands of sapling-size trees (3.5-4.5 inches d.b.h.) were clearcut or thinned to 20, 60, or 100 square feet of basal area per acre or when pole-size stands (6-7.5 inches d.b.h) were clearcut or thinned to 20 square feet of basal area per acre. Total shrub cover was increased, but there was no change in the total cover of other understory plants, when pole-size stands were thinned to 60 or 100 square feet basal area per acre.

Results of this continuing study will provide needed information about the effects of ponderosa pine management on the amount, kind, and value of understory vegetation as white-tailed deer habitat.

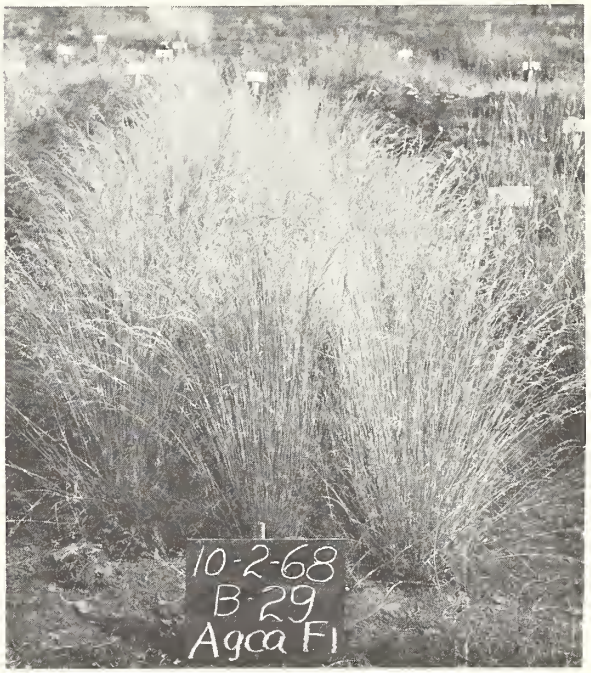
A

B

An almost pure stand of bearberry occupied the site (A) before the sapling-size ponderosa pine was thinned to an actual basal area of 16 square feet per acre. After six growing seasons, the understory contained several grasses, forbs, and shrubs (B).

SPANISH FORAGE SPECIES PRODUCE WELL ON BLACK HILLS MEADOWS

Several Spanish grass and legume species have shown good forage production during their second growing season on meadows in the Black Hills. Low production of Kentucky bluegrass, which dominates many meadows, stimulated a search for more productive deer and livestock forages. Grasses which produced more than 1 ton of dry matter per acre included a bentgrass, illustrated below, and three fescues (sheep, meadow, and red). Although a species of Spanish alfalfa was the best producing legume, production was only about half that of the better grasses.



SHARP-TAILED GROUSE CONSUME OVER 40 GRAMS OF FOOD PER DAY DURING THE WINTER

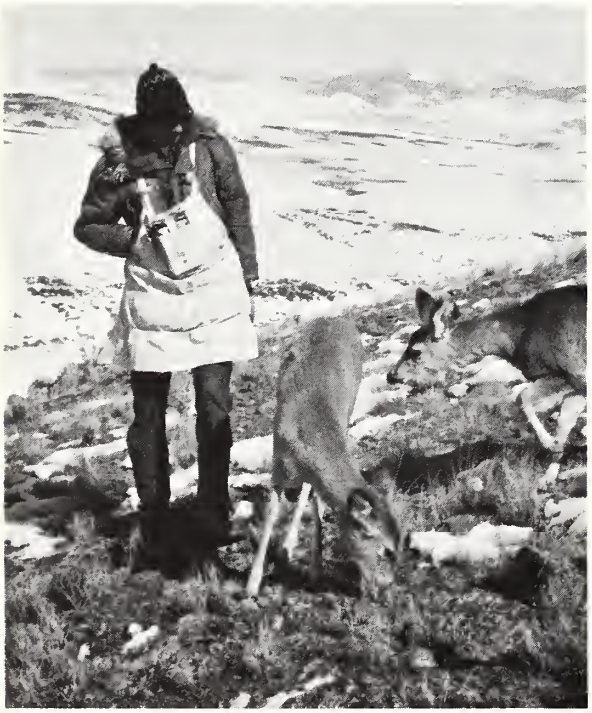
Sharp-tailed grouse consumption of eight different pen-fed diets during February and March averaged 40.2 grams per day in South Dakota.

The birds weighed about 1,000 grams, and daily consumed 2.6 to 4.8 percent of their body weight. They preferred corn to wild berries, plains cottonwood buds, and poultry mash. The low cottonwood bud consumption was surprising since grouse are known to feed on buds for extended winter periods. Grouse on a berry diet ate an average of 380 western snowberries and 53 rose hips per day. Rose hips were from Woods and Arkansas roses. Birds on a corn-only diet ate approximately 174 kernels per day. Precise determination of sharp-tailed grouse food requirements points the way for better habitat management.

SNOW DEPTH GOVERNS TYPE OF FORAGE EATEN BY DEER

Forbs and grasses have been considered unimportant as deer forage on the Western Slope of the Colorado Rockies. In a recent study, however, tame deer used them in proportion to their availability, which was determined by snow depth. Browse use was high only when there was continuous deep snow, and highest when the snow was deep and crusted.

Winter food supply is the major limiting factor of mule deer in the Central Rockies. Studies in cooperation with the Colorado Division of Game, Fish and Parks and Colorado State University are continuing on both winter and summer range to determine forage preferences of mule deer, and methods for increasing the abundance and availability of palatable and nutritious forage.



Tame deer, which provide an indication of forage eaten by their wild counterparts, are forced by snow accumulation to use areas where forage quality is often low.

NUTRIENT INTAKE BY SOUTHWESTERN DEER APPEARS ADEQUATE

Diet composition and nutritional analyses were combined to estimate the average seasonal intake of protein, phosphorus, calcium, and acid-detergent fiber by deer. Selectivity of the animals for superior quality plant parts suggests that the averages calculated from hand-clipped samples may underestimate protein, phosphorus, and calcium while overestimating fiber. Averages were remarkably similar for desert mule deer and Coues white-tailed deer.

Protein intakes varied between 10 and 14 percent yearlong. Phosphorus intake fell slightly below the 0.25 percent minimum requirement during December and January. Calcium levels were excessively high only in December (P:Ca ratio 1:9). Fiber intake was nearly constant at about 35 percent yearlong.

RADIO TELEMETRY USED TO STUDY ABERT SQUIRREL MOVEMENT

Miniature transmitters are being used to study the movement and habits of the Abert squirrel in southwestern ponderosa pine forests. Adult squirrels are anesthesized with pentobarbital sodium while the harness and transmitter are attached. Intramuscular injection in the hind leg produces anesthesia in 5 to 10 minutes which lasts from 45 to 90 minutes.

Diameters of 360 ponderosa pines with squirrel cuttings underneath were recorded over a 4-year period to determine if there was a tree size preferred by the Abert squirrel; 82 percent of the trees were 16 inches d.b.h. and over. The smallest tree with clippings was 4 inches and the largest 36 inches. The average diameter was 19.9 inches.

Anesthesized Abert squirrel with transmitter.

FOREST BIOLOGY

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

POCKET GOPHER POPULATIONS ARE UNAFFECTED BY LIVESTOCK GRAZING

Cattle use of Thurber fescue-forb range in summer and fall on Black Mesa in western Colorado had no apparent influence on northern pocket gopher numbers. Pocket gophers averaged from 16 to 18 per acre over a 13-year period on areas grazed at three intensities. Peak populations of 28 and 30 gophers per acre during the study resulted in considerable soil disturbance. Differences in total herbage production were small between areas with and without pocket gophers.

In years of large pocket gopher populations, numerous soil casts are exposed as the snowpack recedes in spring. Soil casts are made by these animals in winter as they clean and extend their underground burrow system by pushing soil into tunnels made in the snowpack.

POCKET GOPHERS HAVE A 4-YEAR TURNOVER PERIOD

Average survival of northern gophers live trapped, marked, released, and retrapped, based on 8 years of live trapping at Black Mesa in Colorado, was 39 percent the first year following initial tagging, 17 percent the second year, 13 percent the third year, and zero the fourth year. Only eight pocket gophers, originally caught and marked as young-of-the-year, were recaptured for three successive years after initial capture; none was caught four successive years. The live-trapping operation suggests a turnover period—the length of time required for a given age group to be replaced by its descendents—of 4 years for pocket gophers.

Pocket gophers were live trapped, marked, released, and retrapped to learn about population size, age composition, and survival rates on Black Mesa in western Colorado.

EFFECTS OF SAGEBRUSH REMOVAL ON WILDLIFE UNDER STUDY

Wildlife populations are being sampled on two watersheds near Saratoga, Wyoming. One of the watersheds will be sprayed to remove sagebrush. Brewer's sparrow is now the most abundant of four nesting non-game bird species, and the white-footed mouse is the most prevalent of seven rodent species occupying the watersheds. Sage grouse, white-tailed jackrabbits, badgers, and antelope are found on both areas. Subsequent sampling after treatment will permit a more objective appraisal of herbicide treatment effects on wildlife.

Sage grouse depend on sagebrush for winter food. During the summer they occupy stream sides and meadows where they feed on both herbaceous vegetation and sage.

MEADOW OVERGRAZING INHIBITS TURKEY USE

Summer and fall sightings of Merriam's turkeys in the meadows of the Grasshopper Study Area on the White Mountain Apache Indian Reservation in Arizona declined sharply in 1968 compared to 1966 and 1967. Heavy grazing by cattle from May through October 1968 kept the meadows cropped to the ground. Important turkey foods normally present during the summer and fall were almost completely eliminated. As a result, turkeys reverted to the woodlands where good mast crops were produced in 1968.

The grasses, forbs, and insects produced on forest meadows contribute much to the year-long diet of turkeys, especially during the summer and fall. Data obtained on the Grasshopper area show that grasses comprised 38 and 60 percent of the total fall diet in 1966 and 1967, respectively, as compared to only 6 percent during the same period in 1968.

This thinned second-growth ponderosa pine stand has about 435 trees per acre which average 5.8 inches in diameter. Canopy density is about 41 percent. According to the equations, a 0.75-inch rainfall would yield 0.64-inch throughfall and 0.03-inch stemflow for a total net rainfall of 0.67 inch, or 89 percent of the amount reaching the ground in the open.

WATERSHEDS

NET RAINFALL IS RELATED TO FOREST CANOPY DENSITY AND TREE SIZE

The amount of rainfall through a forest canopy (throughfall) decreases with increasing canopy density, and flow down a tree trunk (stemflow) increases with tree size. These basic facts are no surprise to anyone who has sought shelter from heavy rains in a dense forest. However, few scientific studies have yielded sound quantitative bases for predicting these important forest-rainfall relationships.

Throughfall and stemflow are both dependent, of course, on total rainfall. Studies in a Black Hills second-growth ponderosa pine forest indicated that throughfall can be adjusted for canopy density and stemflow can be adjusted for tree size. The canopy variable used was average percent density in a full circle, from vertical to 52 degrees down from vertical, and was estimated from photographs taken upward from near the forest floor. The variable used to adjust stemflow for tree size was trunk diameter at 4½ feet above the ground.

Two equations were developed. One estimates throughfall from total rainfall and average canopy density. The other estimates stemflow from total rainfall and trunk diameter. Used together, the equations can provide an estimate of net rainfall for varying forest densities. An illustration of the procedure follows.

This unthinned second-growth ponderosa pine stand has about 2,885 trees per acre which average 3.5 inches in diameter. Canopy density is about 66 percent. According to the equations, a 0.75-inch rainfall would yield 0.57-inch throughfall and 0.06-inch stemflow for a total net rainfall of 0.63 inch, or 84 percent of the amount reaching the ground in the open.

GRASSES PROVIDE RAPID PROTECTION FOR BURNED AREAS

About 60 percent ground cover density (live vegetation plus litter) was found necessary for adequate control of summer storm runoff and soil erosion from small plots on the Deadwood Burn in the Black Hills. A small proportion of the burned area reached this level of ground cover density in the first growing season after the fire, due mainly to quick establishment of seeded timothy, smooth brome, and Kentucky bluegrass. These grass species were especially important because of their dispersed growth and the abundance and persistence of the litter they produced. Practically all of the sampled area reached 60 percent or more ground cover by the end of the fourth growing season. Runoff and soil erosion rates declined to insignificant levels. Indications are that the risk of damaging runoff and soil erosion would have persisted much longer had the area not been seeded.

DATA BEING COLLECTED FOR "WEST-WIDE AVALANCHE HAZARD RATING INDEX"

Weather, snow, and avalanche data are being collected at 42 locations in 12 western States as a step in the development of an "avalanche hazard rating index." Such an index combined with a mountain weather forecast would help Forest Service land managers predict the avalanche potential of specific back-country areas.

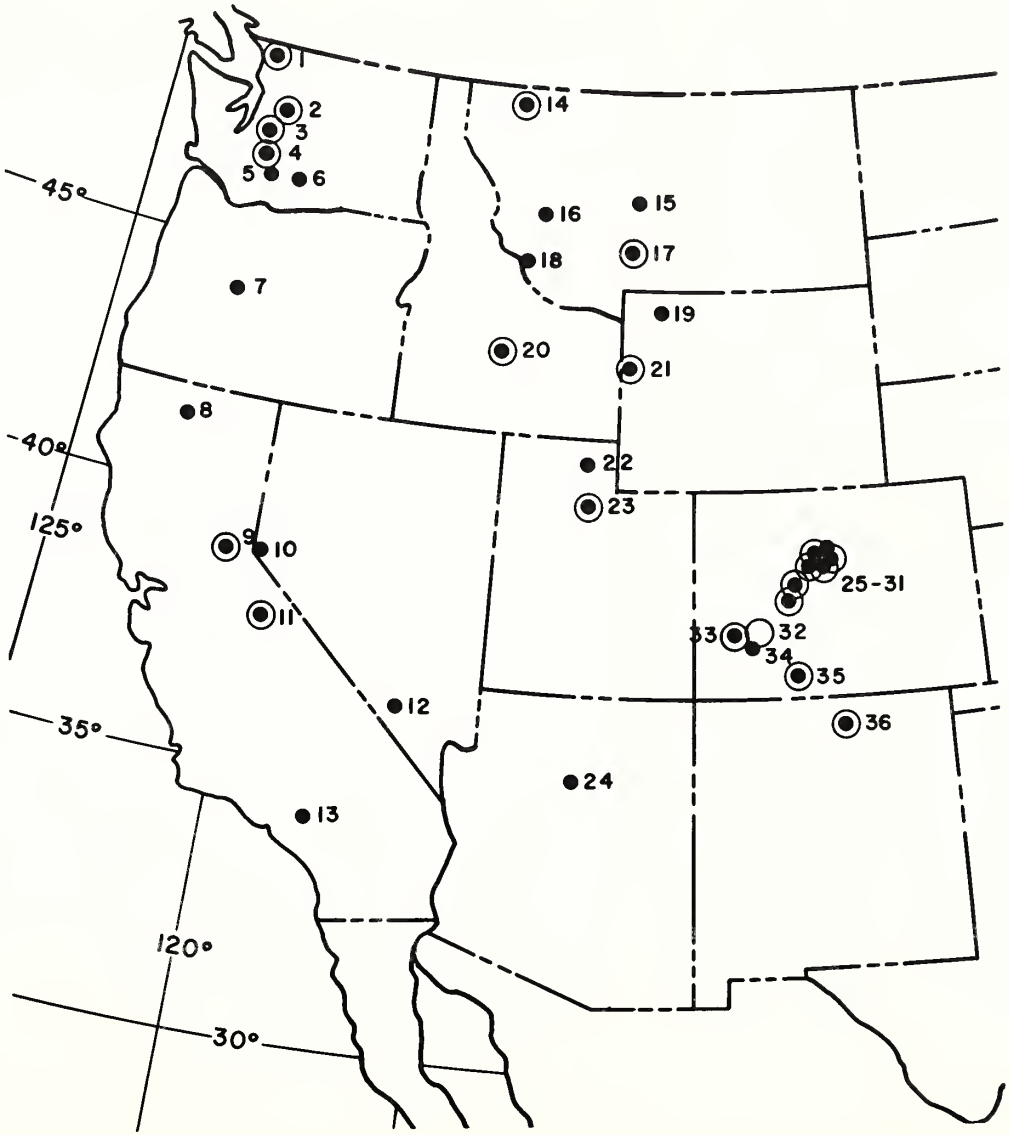
The data network represents a wide variety of weather, snow, and avalanche conditions. Reporting stations cover 25 degrees of latitude and vary in elevation from near sea level in Alaska to 11,300 feet in Colorado. Data are collected by personnel of the U. S. Forest Service, the Colorado State Highway Department, numerous ski areas, and several mining companies. The information is mailed to the Forest Service snow and avalanche research project in Fort Collins where it is compiled. Monthly summaries are returned to the reporting station.

The avalanche problem at 21 of the 42 stations is considered serious. Avalanche specialists at these high-hazard areas make detailed observations of weather and snow conditions which determine when traffic restrictions and avalanche control are needed.

Computers will be used to analyze the data. Relationships will be established between weather and snow conditions and avalanche occurrence. Data from Berthoud and Loveland Passes in Colorado will be analyzed first because good information is available from those areas for 18 consecutive years. Data from additional stations will be used to verify and broaden the results of the initial study. Ultimately, the "avalanche hazard rating index" could be used as the basis of an avalanche warning service for the western United States.

The Deadwood Burn, as photographed in the spring 7 months after the fire.

MAJOR REPORTING STATIONS
OF THE
WEST-WIDE WEATHER, SNOW AND AVALANCHE
REPORTING NETWORK
Forest Service, U. S. Department of Agriculture



1. Mount Baker
2. Stevens Pass
3. Alpental
4. Crystal Mountain
5. White Pass
6. Mission Ridge
7. Bachelor Butte
8. Mount Shasta
9. Alpine Meadows
10. Slide Mountain
11. Mammoth Mountain
12. Lee Canyon
13. Mount Baldy
14. Big Mountain
15. Kings Hill
16. Missoula Snow Bowl
17. Bridger Bowl
18. Lost Trail Pass
19. Sleeping Giant
20. Sun Valley
21. Jackson Hole
22. Snow Basin
23. Alta
24. Arizona Snow Bowl
25. Berthoud Pass
26. Urad Mine
27. Vail
28. Loveland Pass
29. Arapaho Basin
30. Aspen
31. Crested Butte
32. Idarado Mine
33. Camp Bird Mine
34. Red Mountain Pass
35. Wolf Creek Pass
36. Taos

The two Alaska reporting stations not shown are at Alyeska Ski Area near Girdwood and Douglas Ski Bowl near Juneau.

○ Weather
● Avalanches

THEORETICAL HEAT FLOW MODEL PREDICTS SNOWPACK TEMPERATURE VARIATIONS IN SUBALPINE FOREST ZONE

Accurate snowpack temperature information is needed to predict the onset of melt and subsequent rise in streamflow from timbered snow-zone watersheds. Once the snowpack begins to yield water, it responds differently to meteorological events than does a coldpack. The effects of aspect, canopy shade, and elevation are little known.

At the Fraser Experimental Forest in Colorado, snowpack temperature profiles were taken once a week in 1968 and 1969 along a snowcourse traversing the 667-acre Deadhorse watershed. Temperature of the snow was measured with a thermistor mounted on a probe. These controlled measurements were used to test the suitability of an unsteady heat flow model for simulating snowpack temperatures in the forested subalpine zone. The model relates air temperature variations to the consequent temperature profile within the snowpack. Total heat energy input to the snowpack is represented by air temperature measured some 3 to 4 feet above the snow surface.

Results thus far show good agreement between simulated snowpack temperatures and temperatures actually observed in the field.

INCREASED RUNOFF PERSISTS AFTER FOOL CREEK TIMBER HARVEST

Annual runoff has averaged 3.4 inches per year higher during the 13 years since a timber harvest on the Fool Creek watershed of the Fraser Experimental Forest in Colorado. Fifty percent of the merchantable timber was cut in a pattern of alternate cut and uncut strips. The treatment effect has been greatest in wet years and least in dry years. There is no indication that the effect has decreased with time.

Experiments elsewhere have shown fairly rapid loss of treatment effects, with streamflow returning to near pretreatment levels in 15 to 20 years. The apparent reasons for the longevity of the effect at Fool Creek are the slow growth of new vegetation and the strong influence that the leave strips of old-growth timber have on windflow and snow accumulation. Plot experiments show that these snow accumulation effects can last at least 30 years.

WATER YIELD INCREASING FROM WORKMAN CREEK

The third treatment on North Fork and second treatment on South Fork of Workman Creek in central Arizona are nearing completion.

The overall objective on North Fork is to determine by progressive steps of vegetation re-

Snow temperature profiles were easily obtained in the field with a thermistor mounted on a probe. Temperature changes of 0.1° C. were detectable.

moval how the type and amount of vegetation influence water and sediment production. Two sites, the riparian (Arizona alder and bigtooth maple) and the moist site (white fir and Douglas-fir) have been cleared and planted to grass. Results have been published. Under the third and current treatment, dry site vegetation (merchantable ponderosa pine) is being cleared on about 99 acres of the 248-acre watershed. Grass will be planted following slash burning.

The second treatment on South Fork is to determine the effect on water and sediment yield when the entire watershed is managed for the minimum stand (40 square feet of basal area per acre) of ponderosa pine necessary for timber production. Under the second treatment all white fir and Douglas-fir were removed regardless of size, all ponderosa pine sawtimber was harvested and that remaining was thinned to a basal area of 40 square feet per acre, and areas not adequately stocked with ponderosa pine were planted.

Though some slash remains and parts of the treatments are incomplete, water yield increases are indicated for both the North and South Fork watersheds.

MOST WATER YIELD OCCURS DURING SNOWMELT SEASON

During 1967-68, the West Fork of Castle Creek in eastern Arizona yielded 7.7 inches of runoff, the highest since measurements were begun in 1954. Runoff during February, March, and April accounted for 98.8 percent of the year's yield. Of this, 44.2 percent was measured during March.

STREAM CONTAMINATION MINOR FROM FENURON CHAPARRAL TREATMENT

Fenuron contamination of stream water has remained low following chaparral treatment in central Arizona. Pelleted fenuron was applied at the rate of 23 pounds active fenuron per acre to 38 acres of mixed chaparral along the major stream channels of the 246-acre Whitespar B watershed. The soil in the treatment area is a fine gravelly sandy loam of granitic origin.

Water samples collected at the gaging station were chemically analyzed for fenuron. Fenuron detected in the stream before rain occurred was probably the result of direct stream contamination during treatment. The highest fenuron concentration detected in the stream water was 0.43 p.p.m. following heavy rains 33 days after treatment. Subsequent concentrations during the first year ranged from 0.06 to 0.28 p.p.m.

One year after treatment, cumulative rainfall at the stream gage was 27.2 inches, cumulative streamflow was 2.2 inches, and the fenuron concentration was 0.06 p.p.m. During the second year the fenuron concentration ranged from 0.014 to 0.05 p.p.m. Cumulative rainfall for the 2-year period was 49.9 inches and streamflow was 4.4 inches.

Only small amounts of fenuron left the watershed in streamflow.

CHEMICAL CHAPARRAL TREATMENT BRINGS RAPID STREAMFLOW RESPONSE

Dry-season streamflow increased substantially soon after chaparral on a 68-acre watershed in central Arizona was chemically treated. In February, 200 pounds per acre of 10 percent active Tandex granules were spread by helicopter. Within 5 days, heavy rains carried the chemical into the soil where it was picked up by the roots of the plants as the growing season progressed. Shrubs began showing effects of the chemical in April, and by early June susceptible plants were dying and other shrubs had heavy top damage.

Even though little rain fell after mid-March, streamflow remained higher than normal. By mid-May, flow was twice the expected pretreatment rate, and by the end of June the difference was even larger. Rainfall was normal for the period.

These results demonstrate the possibility of increasing local water supplies in chaparral areas during the dry season when even small streamflow increases can be very beneficial to wildlife and livestock.

PARTIAL TOP REMOVAL REDUCES MOISTURE STRESS IN BIRCHLEAF MOUNTAINMAHOGANY

Removal of 40 percent or more of the top from birchleaf mountainmahogany shrubs in the Three-Bar watersheds of central Arizona resulted in a significant drop in internal water stress. Removal of 22 percent of the leaf mass had no effect on moisture stress, while removal of 36 percent resulted in a small but statistically significant decrease.

The pressure chamber or Scholander bomb technique used permits detection of changes in moisture or stress within leaves and small twigs, and by inference, in the soil mass beneath the shrub.

These tentative findings suggest that a high degree of shrub control may be needed before significant soil moisture savings are achieved.

EVAPORATION FROM BARE SOIL AFFECTED BY TEXTURE AND TEMPERATURE

Soil moisture, greatly affected by surface evaporation, is critical for establishing grasses in the Rio Puerco watershed soils of northern New Mexico. Evaporation under several drying conditions was studied in six of these soils ranging in texture from loamy sand to clay.

Sandy soils lost half of their moisture by evaporation in 5 days at 90° F. and 7 days at 60° F., compared to 8 and 15 days for clay soil under similar conditions. Evaporation rates in May and June were nearly twice those in September.

When 0.25-and 0.5-inch increments of water were added to dry soils the evaporation rates were nearly the same on all soils. However, by the time half of a 1-inch application had evaporated, evaporation rates were considerably lower in the finer textured soils than in the sandy soils.

When soils were deeply wetted, heat and moisture transmission properties of the soil played a prominent role in controlling evaporation. When applications were small, these properties had a negligible effect on evaporation.

FOURWING SALTBUSH SUCCESSFULLY TRANSPLANTED FOR EROSION CONTROL

Rapid growth and palatability make fourwing saltbush a desirable plant for erosion control. Direct seeding is not always successful. Techniques for growing fourwing saltbush from seed in hotbeds and for transplanting 4- to 6-week-old seedlings have been developed in the Southwest.

Seeds should be collected from the planned transplant area. Seedlings develop best when (1) the plant bands in which the seedlings are grown are placed on an impermeable plastic layer, (2) valuable micro-organisms are added to the soil mix, and (3) planting is done at a temperature of 65° F.

Seedlings should be transplanted in moist soil before 10:00 a.m. during late July or early August. The transplant area should receive periodic flooding but should not be inundated for periods longer than 30 hours. Covering with straw and spraying with animal repellent after transplanting aids survival.

Six-week-old fourwing saltbush transplants growing in 2- by 2-inch plant bands ready for field planting.

One-year-old transplanted fourwing saltbush. Plants are about 1.5 feet tall.

TAMARISK ARBORETUM STARTED AT ARIZONA STATE UNIVERSITY FARM

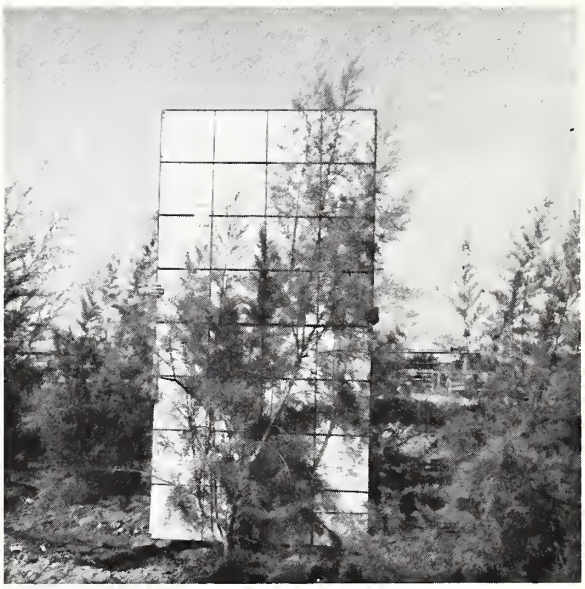
The deciduous tamarisk or saltcedar which has invaded hundreds of thousands of acres of flood plains, streambanks, and reservoir deltas in the western United States, has been found to be extremely variable in its growth and flowering habits. This may help explain the difficulty encountered in herbicide control of tamarisk. As a guide in control activities, it is desirable to understand and classify the strains of tamarisk found in the West. Consequently, a living collection of tamarisk has been started at the Arizona State University Experimental Farm east of Tempe. Many strains from various parts of the United States and the Old World have been planted side by side to detect genetic differences.

A group of tamarisk showing wide differences in characteristics growing in an isolated, very dry area of the Salt River wash near Tempe, have been reestablished at the farm by vegetative cuttings. These plants had been studied for several years to determine normal differences in flowering and growth habits. Some shrubs bloom only in the spring, some only in the summer, and others bloom almost throughout the flowering season. After planting on the farm, the color of the flowers, the size and shape of panicles, and the color of the foliage has remained con-

sistent, even though their environment has radically changed from a sandy desert wash with an extreme moisture deficiency to a location with sufficient water and fertile soil. Thus, the variability in plant characteristics seems to be due to genetic rather than environmental factors.

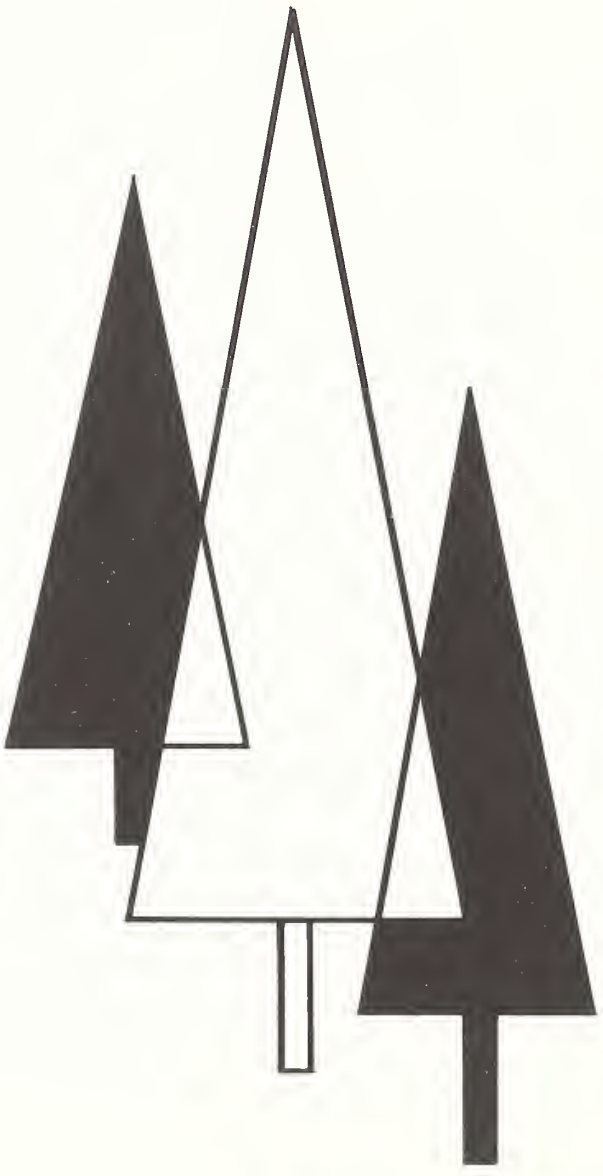
It has also been found that the flowers of tamarisk are entirely insect pollinated. To study the progeny of one shrub or the cross of two strains it is necessary to remove the blooms from all other nearby shrubs. Both types of study are underway and new seedlings are growing.

Five-stamen tamarisk is typically an open-grown shrub similar to this plant growing on the Gila River wash south of Buckeye, Arizona.



This shrub of smallflower tamarisk was grown on the Arizona State University Experimental Farm from a cutting received from Israel. It is quite similar in growth habit to fivestamen tamarisk but blooms only in the spring.

GROWING TOMORROW'S TREES



KININS CAUSE FASCICLE BUD DEVELOPMENT IN PINE

In tree improvement research, vegetative propagation is a necessary means of multiplying plants with the same hereditary makeup as the original plant. Vegetative propagation of small ponderosa pine trees is often restricted by lack of enough branch tips for scions. Kinins may be useful in increasing the number of available scions by causing development of the normally dormant primordium in the base of needle fascicles. Application of 6-benzylaminopurine either as a lanolin paste at 1,200 p.p.m. or in aqueous solution at 50 p.p.m. from a wick sewn through the bud caused development of up to 20 new shoots from a single bud.

Kinin in aqueous solution delivered by a cotton wick sewn through a ponderosa pine bud caused needle fascicle buds to develop whole new shoots.

GOOD SPRUCE SEED CROPS OCCUR INFREQUENTLY

One good seed crop (100,000 or more sound seeds per acre) and two moderate crops (50,000 to 100,000 sound seeds per acre) were recorded under uncut Engelmann spruce stands along the margins of two 400-foot-wide clearcut strips on the Fraser Experimental Forest in Colorado during the period 1956 to 1965. Seed production was poor or nearly nonexistent during the other 7 observation years. Infrequent seed crops mean natural reproduction cannot be expected every year.

Seedfall into the clearcut openings from standing timber was not uniformly distributed over the openings, but decreased as the distance from the source increased. Although about one-half of the total number of sound seeds dispersed in years of moderate-to-good seed production fell within 65 to 100 feet of the timber edge, seed in significant quantities (at least 10 percent of the total) was dispersed across the openings. Seed supply does not, therefore, appear to be the factor limiting regeneration success in small openings.

BLACK HILLS PINES SET NEW GROWTH RECORDS

Four to six inches of diameter growth per decade from managed ponderosa pine stands may sound unobtainable to Black Hills foresters conditioned to expect no more than 1.5 to 2.0 inches of growth in the same period. Such rates have been attained by a majority of trees in three experimentally thinned stands growing on Black Hills sites of average quality. By the end of the sixth year after thinning, 8 out of 10 trees were growing at average annual rates of 0.4 inch or more. During the sixth growing season, in 1969, a few trees achieved 0.7 inch diameter increment.

This unprecedented growth response resulted from thinnings which were uncommonly heavy by Black Hills standards. Only 60 to 70 pole-size trees and about 15 square feet of basal area per acre—roughly one-fifth the reserve stocking recommended by current thinning guides—remained after thinning. Hence, the few trees retained are growing virtually free of competition.

For now, results merely improve our understanding of the growth potential of Black Hills ponderosa pine. Practical implications remain to be evaluated. If diameter growth rates of 4 to 6 inches per decade can be achieved and maintained for even 2 or 3 decades, timber crop rotations can be markedly shortened. The effect of extremely rapid growth on wood quality and the effect of low stand density on total yield must still be evaluated.

An unprecedented growth rate resulted when ponderosa pine was heavily thinned in the Black Hills. Only 60 to 70 pole-size trees and about 15 square feet of basal area per acre remained after thinning.

SHADE IS CRITICAL FOR SURVIVAL OF PLANTED SPRUCES

Field shade consistently increased survival of planted Engelmann spruces in several planting trials. In contrast, various preplanting treatments —combinations of shade and no shade in the nursery and holding beds near the planting site— did not increase field survival.

Several environmental factors, including gophers and freezing injury to new growth during the growing season, contributed to mortality after field planting. Unshaded seedlings were especially susceptible to frost injury, but during summer nights when frost was severe, shaded seedlings were also damaged.

The primary cause of death of unshaded seedlings, however, was solarization, a phenomenon characterized by yellowing of foliage and caused by extreme light intensities that destroy chlorophyll and inhibit photosynthesis. Although survival of both shaded and unshaded seedlings decreased steadily during successive seasons following planting, survival of shaded seedlings at the end of 5 years was still two to three times higher than that of unshaded seedlings.

Since mineral deficiency—often nitrogen—may also cause yellowing of foliage, seedlings were analyzed to determine if nitrogen deficiency was related to changes in foliage color. There were no significant differences in the nitrogen content of shaded and unshaded spruce seedlings.

PHOTOSYNTHESIS OF SUN AND SHADE PLANTS COMPARED

Knowledge of photosynthetic response of seedlings to light enable us to select or create the environment necessary for their survival.

Potted Engelmann spruce (3-0 stock) and lodgepole pine (2-0 stock) seedlings, grown in the shade and in the open for one summer, were measured in September to determine photosynthesis at light intensities up to 12,000 foot-candles. Spruce seedlings (shade plants) reached near-maximum photosynthesis at about one-third full sunlight. However, pine seedlings (sun plants) did not reach maximum photosynthesis until light intensities approached full sunlight. The similar photosynthetic response of shaded and unshaded spruce seedlings to increasing light intensities indicated that spruces behave like shade plants regardless of previous growing conditions. If the photosynthetic mechanism of unshaded spruces had adapted to high light intensities, their response should have been similar to that of pine.

EVALUATING MULTIPLE FOREST USES

PRELIMINARY RESULTS FROM MULTIPLE USE EVALUATION OF BEAVER CREEK WATERSHED TREATMENTS

Preliminary results are available from a series of treatments that have been underway since 1963 on the Beaver Creek Watershed in central Arizona. An interdisciplinary team of scientists is evaluating alternative ways of increasing streamflow. Treatment effects are measured in terms of production changes in wood, herbage, wildlife habitat, and sediment, as well as water. This multiple use evaluation of treatment effects will be supplemented with economic evaluation. Initial results from four Beaver Creek Watersheds are presented in the following items.

UTAH JUNIPER CABLED

The 1963 cabling of Utah juniper (Watershed 1) was generally similar to that applied extensively for range improvement in the Southwest. Trees were uprooted by a heavy steel cable pulled between two bulldozers, slash was burned, and a mixture of forage species was seeded.

Water and sediment yields have not changed significantly, but total herbage production—particularly of forbs and half shrubs—has increased. No meaningful changes in deer habitat and deer use have occurred. The lack of a water yield increase may be due to the similar water requirements of the pretreatment juniper stand and the posttreatment herbaceous cover, which is exposed to increased wind movement and insolation.

Pits were left in the ground after Utah juniper trees were uprooted (Watershed 1).

ALLIGATOR JUNIPER CUT

Alligator juniper watersheds (Watershed 6) are at a higher elevation than the Utah juniper watersheds and consequently receive more precipitation and produce more streamflow. Tree cover is more sparse but production of herbaceous vegetation is generally much greater on alligator juniper watersheds than on Utah juniper watersheds. The 1965 treatment killed all woody vegetation by felling and poisoning. Pitting and other soil disturbances were avoided. Alligator juniper stumps were treated with polychlorinated benzoic acid to reduce sprouting; shrub live oak was treated initially with fenuron and later with picloram; and Gambel oak sprouts were treated with a dormant-season basal area spray of 2,4,5-T. The felled trees were left in place.

Preliminary analysis does not indicate significant differences in water yield or suspended sediment concentrations. Herbage production doubled during the second posttreatment year, but then dropped back nearly to pretreatment levels during the third and fourth years. Effects on deer forage and deer and elk use have been negligible.

PONDEROSA PINE STRIPCUT

One-third of a ponderosa pine watershed (Watershed 9) was cleared in a series of 60-foot-wide cut strips which alternate with 120-foot leave strips. Strips are generally alined in the direction of slope to provide efficient delivery of water to the stream channels. Slash in the cut strips was burned.

The basis for stripcutting was provided by earlier Beaver Creek studies that showed the water equivalent of peak seasonal snowpack can be increased as much as 4 inches by cutting narrow strips in a dense ponderosa pine forest. Snow tends to be trapped in the cut strips, and on certain alinements it is protected from winter melt by shade from adjacent leave strips.

Stripcutting was completed in the summer of 1968, so there has been only 1 year to observe results. Water yield was increased substantially—2.87 inches in water year 1969. However, it is not known how lasting or consistent this increase will be. Sediment yield increased slightly. Herbage production and wildlife habitat values started to show significant increases in 1969.

One-third of this watershed was clearcut in 60-foot-wide strips oriented downslope (Watershed 9).

The clearcut strips in ponderosa pine are designed to trap and retain snow, and to direct melt water into the streams (Watershed 9).

PONDEROSA PINE CLEARCUT

A ponderosa pine watershed (Watershed 12) was clearcut in 1966-67 to provide information on product changes resulting from the most extreme level of vegetation treatment. This was the first in a series of ponderosa pine watershed treatments designed to test a wide variety of treatment responses. It was not intended as a test for a proposed operational practice. Rather, it was a necessary step in developing the relationship between treatment magnitude and treatment response.

A unique feature of this treatment is the arrangement of slash in long parallel windrows 100 feet apart. The windrows are alined either east-west or northwest-southeast to increase the trapping and retention of snow. Followup applications of 2,4,5-T are being made on Gambel oak sprouts to minimize regrowth.

Heavy summer rains soon after the trees were cut and the slash windrowed, resulted in heavy runoff and sediment yields in 1967. In 1968 and 1969, respectively, this watershed yielded 3.8 and 1.6 additional inches of water. This was accompanied by some continued increase in sediment and substantial increases in herbage production and wildlife habitat values, over pretreatment levels.

Windrows of slash trapped and retained snow after ponderosa pine was removed (Watershed 12).

PROTECTING THE FOREST AND RANGE

FOREST INSECTS

SHELTERBELT INSECTS BEING STUDIED

Trees and shrubs of windbreaks and other protective plantings on the northern Great Plains are hosts for more than 300 species of insects. Most seldom cause serious damage; others definitely retard tree growth and delay the effectiveness of wind barriers, hasten the deterioration of established plantings, or impair esthetics. The resources to be protected from damaging insects include plantings to protect fields from wind erosion and farmsteads from heat and cold, as well as plantings for esthetics, recreation, highway safety, noise abatement, and wildlife habitat.

New insect research is underway at Bottineau, North Dakota. Survey methods and identification aids will be developed to bring potential pests under surveillance. Control methods will be devised if necessary; the use of natural enemies and resistant planting materials will be emphasized, and some of the safer and more specific new insecticides will be tested. Research is planned to learn why insect abundance varies from place to place and year to year, so that insect problems can be anticipated and prevented.

These unsightly tents of the prairie tent caterpillar (Malacosoma lutescens) are on chokecherry, an important shelterbelt shrub of the northern Great Plains.

This planting of green ash has been partly killed by bark beetles (Leperisinus californicus).

THREE COMMON MOUNTAIN PINE BEETLE PREDATORS FOUND

Black Hills studies have shown that three kinds of predaceous insects commonly attack the mountain pine beetle **(Dentroctonus ponderosae).** These are **Medetera aldrichii** and **Laphria gilva,** both species of flies, and **Enoclerus sphegeus,** the red-bellied clerid beetle. Both larvae and adults of **E. sphegeus** feed on the mountain pine beetle; **M. aldrichii** larvae feed on beetle eggs and larvae, and **L. gilva** adults catch adult mountain pine beetles in flight. Although these three predators attack the beetle at several points in it life cycle and do contribute to its regulation, they appear unable to check beetle outbreaks by themselves. As forest management becomes more intensive, however, integrated control methods capitalizing on the predators' potential will undoubtedly be employed.

This red-bellied clerid beetle is killing a mountain pine beetle.

SHADED LOGGING RESIDUE MOST FAVORABLE FOR SPRUCE BEETLE DEVELOPMENT

While it has generally been acknowledged that logging residue can contribute to the buildup of spruce beetle **(Dendroctonus rufipennis)** populations, quantitative guidelines to help the forest manager determine when a situation is hazardous have not been available. Research started in 1968 has shown that shading is highly beneficial to development of spruce beetle broods. North sides of stumps and undersides of cull logs produce the greatest numbers of beetles. Logging residue in cool, shaded locations remains suitable for attack and production of beetles for at least 2 years.

WOODPECKERS IMPORTANT SPRUCE BEETLE PREDATORS

Birds—primarily woodpeckers—are major factors in controlling spruce beetle outbreaks. Three species of woodpeckers have ranges that coincide with those of spruce stands and the spruce beetle. One of these, the northern three-toed woodpecker, is the most important avian predator of the spruce beetle and it is rarely found in other than spruce stands. The hairy and downy woodpeckers, olive-sided flycatcher, mountain chickadee, mountain bluebird, and gray-headed junco also reduce spruce beetle numbers.

BUDWORM BIBLIOGRAPHY PUBLISHED

The complex of spruce budworm **(Choristoneura)** species presents one of the most serious and widespread forest insect problems in North America. As such, it is the subject of much literature. All of the literature published on the species prior to 1968, some 370 articles, has been reviewed and listed in a comprehensive bibliography. This publication (Research Paper RM-44) will be especially helpful to students and scientists undertaking budworm studies as it will significantly reduce the time needed to properly search the literature for pertinent articles.

SEX ATTRACTANTS HELP EVALUATE MOTH INFESTATION TRENDS

The southwestern pine tip moth **(Rhyacionia neomexicana)** is causing widespread damage to new plantations and natural reproduction of ponderosa pine in the Southwest. By attacking the growing tips it severely impedes growth and distorts the form of most affected trees.

This tip moth overwinters in pupal cases attached to the base of small ponderosa pine trees below ground level. The adult moths emerge in the spring—males preceding females by about 10 days. They mate, and the females lay eggs on the inner surfaces of the previous year's needles.

The year-to-year moth population in plantations can be determined by means of sex traps. These traps are made by caging three virgin female moths in a screened ice cream carton. The carton is placed in the center of a 10-foot-square piece of hardboard coated with a sticky substance. Male tip moths are lured to the traps by the virgin females and become stuck. As many as 255 male moths were captured on a single trap overnight. Attraction began around 8:00 p.m. and continued until about 11:00 p.m. None were caught during daylight. Traps with virgin females are attractive to males for at least three consecutive nights.

Male southwestern pine tip moths caught on a sex trap coated with a sticky substance. The males were lured to the trap under field conditions by virgin females enclosed in a cage on the center of the trap.

FOREST DISEASES

PHOMOPSIS BLIGHT CONTROLLED ON ESTABLISHED EASTERN REDCEDAR

Previous work has shown that **Phomopsis juniperovora** can be controlled in the nursery by weekly applications of phenyl mercury fungicides. Current work shows that the same fungicides can control this fungus on outplanted eastern redcedar. Three applications a month apart beginning in late May are effective.

DOTHISTROMA PINI SPORES SHOW UNUSUAL GERM TUBE GROWTH

Dothistroma pini needle blight causes extensive damage to Austrian and ponderosa pines in shelterbelt, Christmas tree, and landscape plantings in the central and southern Great Plains.

Recently it was found that when spores of this fungus germinate on needles of these pines, their germ tubes grow directly toward stomates, through which they enter the needles.

INOCULATION TESTS PROVIDE GUIDELINES FOR MISTLETOE CONTROL

Results from a series of about 6,000 dwarf mistletoe (**Arceuthobium americanum**) seeds planted on lodgepole pine over a 6-year period show that shoots first appeared from the second to seventh year after planting. Seventy percent of the inoculations first produced shoots in the third or fourth year. Abundant fruiting began in the sixth year for all years' inoculations. On the basis of these findings it is recommended that, in sanitation projects for the control of this mistletoe, stands should be recleaned 3 years after the initial operation.

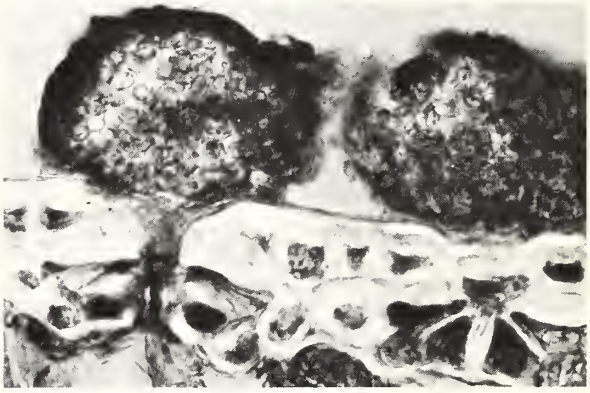
NITIDULIDS LIKELY INSECT CARRIERS OF CERATOCYSTIS ASPEN CANKER

Ceratocystis cankers of aspen usually start at trunk wounds. Aspens were intentionally wounded to attract insects, which were then collected and examined to determine whether they were carriers of the canker fungus. Nitidulids were the most common insect found, and seven species carried six different species of **Ceratocystis** including **C. fimbriata,** the primary causal fungus. Field-collected insects transmitted the disease to wounded aspen in the greenhouse.

An aspen stand severely infected with Ceratocystis cankers.

POTENTIALLY DAMAGING NEEDLE CAST FOUND ON SPRUCE IN ARIZONA

The needle cast fungus, **Rhizosphaera kalkhoffii** is damaging to planted blue spruce and native spruces in many parts of the world, but it was not previously known to occur in native blue spruce stands. Damage to blue and Engelmann spruce stands in Arizona is negligible, and observations suggest that under normal conditions **R. kalkhoffii** would not cause serious damage in native stands of either species.



Photomicrograph of Rhizosphaera kalkhoffii in a blue spruce needle showing a transverse section of mature pycnidium.

FOREST FIRE

NATIONAL FIRE-DANGER RATING SYSTEM BEING DEVELOPED

A new system is being developed that will provide a common basis for forest fire planning and action in all parts of the country. At present, several systems are in use by the different agencies dealing with wild land fires. The new system will encourage uniformity among agencies, and will be more complete and fundamentally related to known physical laws of fire behavior. Three fire control indexes will be provided: an occurrence index, a burning index, and a fire load index.

Recent highlights from this work are presented in the following four items.

DEAD FUELS CLASSIFIED BY HUMIDITY CHANGE RESPONSES

Moisture content is an important determinant of how easily fuels catch fire and how hot they will burn. Dead fuels vary from large logs and deep duff to fine materials such as pine needles and grass. A basis for classifying these dead fuels

has been developed for the national fire-danger rating system. The basis is the timelag between relative humidity changes of the surrounding air and the resulting response of dead plant material. Dead fuels are placed in 1-hour, 10-hour, 100-hour, and 1,000-hour timelag classes.

IGNITION PROBABILITY MODEL COMPLETED

Ignition probability, a measure of the additional heat needed to ignite a fuel particle, is based on the temperature and moisture content of fine fuels when an ignition source is present.

Ignition probability will be combined with a measure of risk to form an occurrence index in the national fire-danger rating system. The occurrence index indicates the probable number of fires that will occur in the area rated. This index in turn is combined with the burning index to form a fire load index, which indicates the potential daily job load.

RATE OF SPREAD MODEL ADAPTED

Rate of spread is an important part of the burning index used in fire-danger rating to indicate the potential containment job on a forest fire. A mathematical model for rate of spread, originally developed by the Northern Forest Fire Laboratory, has been adapted for use in the national fire-danger rating system. The complex model has been set up for easy solution from sets of tables for about 25 fuel models, which include various combinations of living and dead fuels. Information needed to determine the rate of spread includes moisture content of dead fuels in the 1-hour and 10-hour timelag classes, herbaceous stage of fine fuels, moisture content of living fuels, windspeed, and slope.

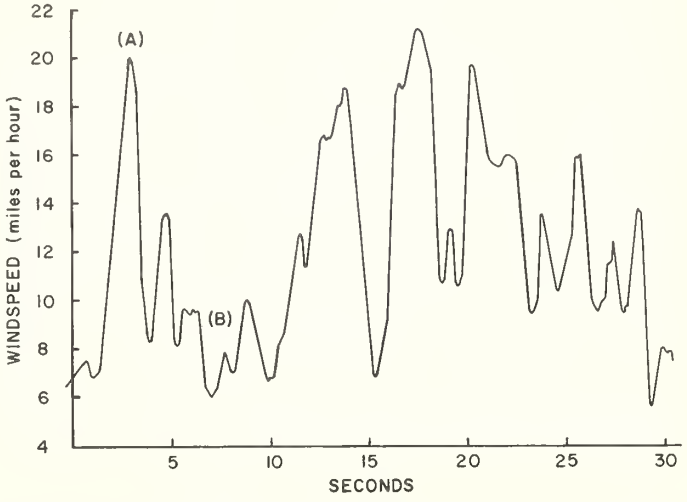
FINE FUEL MOISTURE CONTENT ADJUSTED FOR HERBACEOUS STAGE

Small living vegetation must be considered in the rate of spread equation in the national fire-danger rating system. A convenient method is to make adjustments in the fine fuel moisture content according to the proportion and stage of growth (green or partly cured) of small living vegetation in the total amount of fine fuels. A method for adjusting fine fuel moisture was developed by equating two parallel solutions of the rate of spread equation. One includes the small vegetation as part of the total living fuels; the other considers it as part of the dead fine fuels with an adjusted moisture content.

RESEARCH FURNISHES DATA FOR USE OF PRESCRIBED FIRE

Operational models for doing specific jobs with prescribed fire in Arizona chaparral are being developed from data collected from carefully instrumented research fires burning natural fuels under outdoor conditions.

New wind dimensions—pulse rates and magnitudes—cause more variation in combustion than does average windspeed, the most commonly used wind dimension. Each pulse of wind (a short-term increase of 3 m.p.h. or more) drives the flames into new fuel and increases the burning rate for small, well-ventilated material. Flames burn the larger, more compact fuel during the following lull.



This 30-second excerpt from the wind record during a research fire illustrates the normal undulating pattern of wind. In this instance, the velocity ranged up to 20+ m.p.h. with an average of 11.5 m.p.h. The peaks are pulses (A) and the valleys lulls (B).

CHAPARRAL FIREBRANDS AND SPOT FIRES MAY BE RELATED TO FUEL CHEMISTRY

Research fires in Arizona chaparral have emitted "hot-to-the-touch" firebrands (glowing leaves) only during the peak of the spring growing season. Although firebrands have been emitted at other times, they have been "cool" ash with low potential for kindling fire.

During the peak growing period, low phosphorus and ash content of the leaves distinctly favored glowing combustion, while high potassium, low crude fat, and high moisture content of the leaves discouraged flaming combustion.

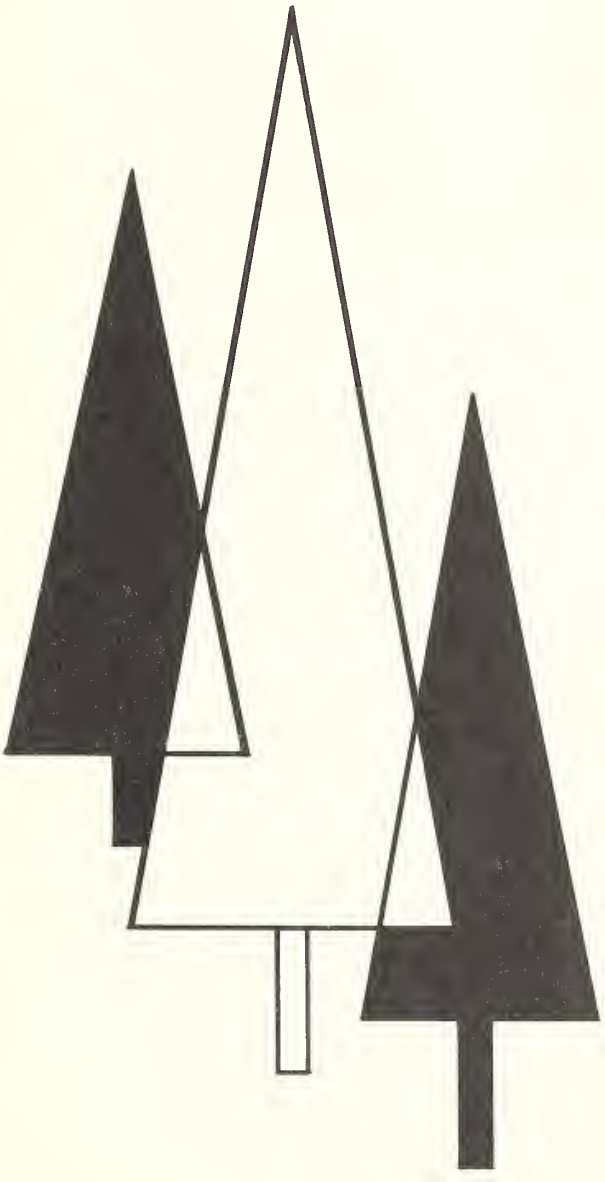
Spotting of fires requires both "hot" firebrands and "tinder-dry" litter beds. Fuel chemistry may be the best measure of the potential for producing hot firebrands, and litter moisture indicates the relative flammability of litter beds. Combustion models for Arizona chaparral probably will include components of both foliar chemistry and litter moisture. Leaf chemistry as it relates to burning characteristics is being thoroughly tested in continuing studies.

A

B

During pulsing wind, fire spreads by intense spurts (A) separated by pauses and less intense burning (B). Pulsing affects both the rate and quantity of energy released by combustion.

USING AND MARKETING WOOD PRODUCTS



FOREST PRODUCTS UTILIZATION

BEST MOISTURE CONTENT FOR LAMINATED BEAMS IS 6 TO 8 PERCENT

Laminated beams perform best when moisture contents during fabrication and during service are about equal. Measurements were taken from a sample of laminated beams in service to determine their moisture contents under central and southwest Rocky Mountain conditions. The measurements were taken seasonally on 20 structures over a period of 3 years, and included both outdoor and indoor conditions. Typical moisture contents of beams exposed outside buildings in the Central Rockies were about 7.5 percent; beams inside buildings had about 6.5 percent moisture. In the Southwest (Albuquerque and Phoenix) moisture contents of both indoor and outdoor beams were 6 to 6.5 percent.

The laminated beams in this supermarket were included in the moisture content study. Beam manufacture provides a way of utilizing small trees for the production of large timbers.

SEASON OF HARVESTING HAS LITTLE EFFECT ON PERMEABILITY OF ROCKY MOUNTAIN WOODS

The permeability of wood affects its treatability with preservatives, and is generally believed to be an important factor in drying wood products. A study was conducted to determine if and how the permeability of lodgepole pine, Engelmann spruce, and Douglas-fir varied by seasons of harvesting. It was hoped that the knowledge gained might indicate an optimum time for harvesting these difficult-to-treat softwood species that would make their wood dry more quickly and be more receptive to preservatives.

The sapwood and heartwood of the three species varied considerably in permeability to liquid and gas during a 2-year study, but there was no significant seasonal variation. Seasonal variations in drying and treating properties of these three species, therefore, must be related to something other than time of harvesting.

DOUBLE-DIFFUSION TREATING METHOD EFFECTIVE FOR ROCKY MOUNTAIN WOODS

The penetration and retention standards of the American Wood Preservers Association (AWPA) for Engelmann spruce, lodgepole pine, and Inland Douglas-fir can be met by the double-diffusion treatment method, according to a recent study.

Green posts are soaked in two chemical solutions during the double-diffusion process. The chemicals, in this case copper sulfate and sodium chromate-sodium arsenate, being water soluble, diffuse into the free water in the wood where they react with each other to form a highly insoluble compound that is toxic to fungi and insects. Only simple equipment and relatively low-cost chemicals are required.

The treatments that appear most effective are the 1-day soak in each of the cold solutions for incised posts, and the 8-hour hot soak in copper sulfate followed by a 1-day soak in cold sodium chromate-sodium arsenate for unincised posts.

Retention rates and penetration depths were two to three times higher for incised than for unincised posts.

The results are especially significant in the treatment of Engelmann spruce, because this species is highly resistant to treatment by customary methods.

LUMBER SPECIFICATIONS DEVELOPED FOR OVERLAID LUMBER PRODUCTS

A tentative set of lumber grade specifications based on tests of paper-overlaid products has been developed. These specify minimum lumber standards for roll-lamination overlaying by considering knots, knotholes, decay, holes, checks, splits, pith, manufacturing defects, and warp. In general, lumber can be successfully overlaid if open defects are no longer than ¼-inch diameter. Some open defects may be repaired with plugs or fillers before applying an overlay. Work is underway to develop technically and economically feasible ways of repairing lumber for overlaying.

Analysis of typical lumber from three southwestern mills showed the following breakdown of suitability for lamination.

Lumber Grade	Acceptable as is	Repairable	Unacceptable
	——percent——		
No. 3 Common	24	67	9
No. 4 Common	8	59	33
No. 5 Common	0	14	86

ROLL-LAMINATING PAPER OVERLAYS ON LUMBER COSTS 4 TO 5 CENTS PER BOARD FOOT

A series of pilot plant tests are being conducted to determine the economic feasibility of upgrading ponderosa pine lumber by applying special paper overlays. Costs of covering one face and wrapping both edges of a board with 5-mil Forbon (vulcanized fiber) varies from 4 to 5 cents per board foot. These costs include overlay material, adhesive, power, labor, and appropriate charges for depreciation, taxes, and insurance.

COMPUTER PROGRAM DEVELOPED TO ANALYZE TIMBER PRODUCT POTENTIAL

A computer program has been developed that will analyze timber inventory data by grading or classifying sampled trees as to their suitability for commercial poles, saw logs, veneer logs, stud logs, or pulpwood. Output tables show gross volume per acre, by grade and size class, independently for each product. An option allows segregation of volumes usable for each product in a multiproduct combination, following a specified order of preference.

The program accepts basic field inventory data that describes stem size, stem form defects, scar defects, and knot characteristics of sample trees. Stems or stem sections meeting minimum size and quality requirements for a product are graded by comparing stem characteristics to grade criteria. Standard product grading systems are used.

The program can be modified to meet specific inventory and analysis requirements. Subroutines can be altered to accommodate other sampling systems, product mixes, or grading systems. Grading criteria can be changed without difficulty.

JUNIPER MAKE DURABLE FENCEPOSTS

Untreated juniper fenceposts locally available throughout the Southwest remain serviceable for many years. During 1938-1940, sample posts of southwestern juniper species were installed in range fences and in test plots. Test areas included both dry desert and forested locations. Four species of juniper were included in the test: one-seed juniper, alligator juniper, Utah juniper, and Rocky Mountain juniper. Essentially all the posts installed in desert areas and from 80 to 100 percent of the posts in forested areas remained serviceable throughout the entire 25-year period. One-seed juniper and alligator juniper performed slightly better than the Utah and Rocky Mountain species, but even the poorest level of serviceability after 25 years was a full 80 percent.

The compounds that make juniper durable occur only in the heartwood. Consequently, split heartwood posts are superior to posts made from the whole stem because the latter type become loose when the sapwood rots.

FOREST PRODUCTS MARKETING

PONDEROSA PINE VOLUME IN THE BLACK HILLS IS ADEQUATE FOR PLYWOOD PRODUCTION

A Black Hills forest inventory showed enough ponderosa pine timber, of the right kind, to support a profitable plywood enterprise. Almost 8 out of 10 trees 9 inches or larger in diameter meet industry standards for veneer yield. Continued research will determine whether there is enough timber to produce plywood in addition to the lumber now produced.

A related study indicates that ponderosa pine plywood production in the Black Hills would be profitable if a plant annually sold at least 24 million square feet (3/8-inch basis). However, the return on investment would be much more attractive if annual production were increased to 36 million square feet. Plants of these sizes would be small compared to mills on the West Coast or in the South, but the higher unit costs of such small plants would be more than offset by lower transportation costs to major markets.

Our analysis of plywood production in the Black Hills will consider not only the technical and economic feasibility of plywood production, but also the probable effects of such production on the local economy.

MOST PLYWOOD IN ARIZONA IS USED FOR ROOF SHEATHING

Nearly 90 percent of all plywood used in the Phoenix trade area (most of the State of Arizona) is used for roofs. Over three-fourths of the building contractors replying to a questionnaire said that plywood was their principal roof sheathing material. Of the plywood used in roofs, four times as much was used in apartments and nonresidential construction as in single-family homes.

Concrete formwork is the second most important plywood application in the Phoenix area. Subflooring, floor underlayment, wall sheathing, and soffits follow in that order.

Price was most often cited as the reason for selecting specific building materials. Cost of installation was important also, as were performance and consumer preferences. Plywood competes very well in the Phoenix area as roof sheathing, wall sheathing, concrete formwork, cabinets, shelving, and millwork. However, it is not strongly competitive for use as exterior siding, subflooring, or roof decking.

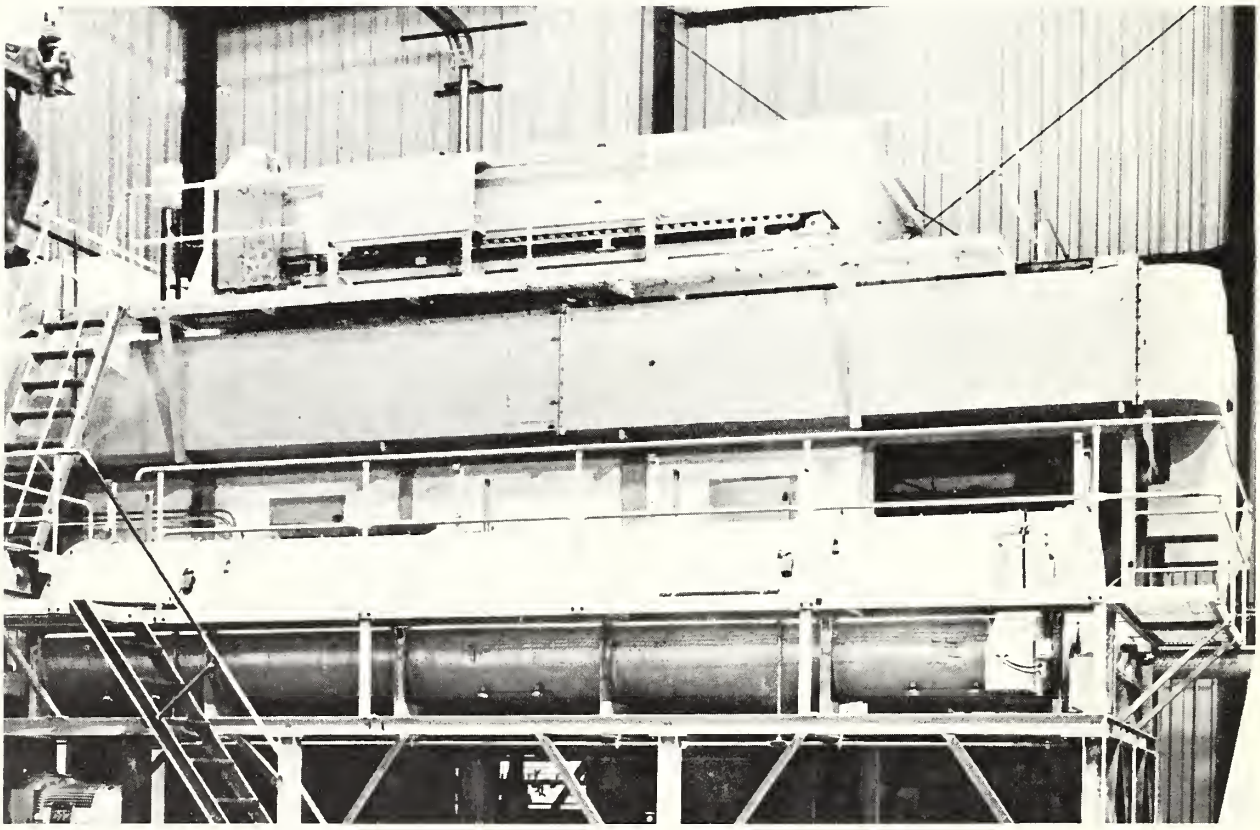
The Phoenix study is one of a series designed to find regional differences in plywood use patterns. This information is needed to know where additional resources and facilities for plywood production can best be developed and located. Local communities benefit by having reliable facts and projections upon which to base economic expansion plans.

NEW MEXICO MAY BE A POSSIBLE SOURCE OF PARTICLEBOARD

Particleboard is one of the new products that will help meet the expanding demand for building products. New Mexico has a surplus of wood-processing residues and small or defective trees which can be efficiently used in particleboard manufacture.

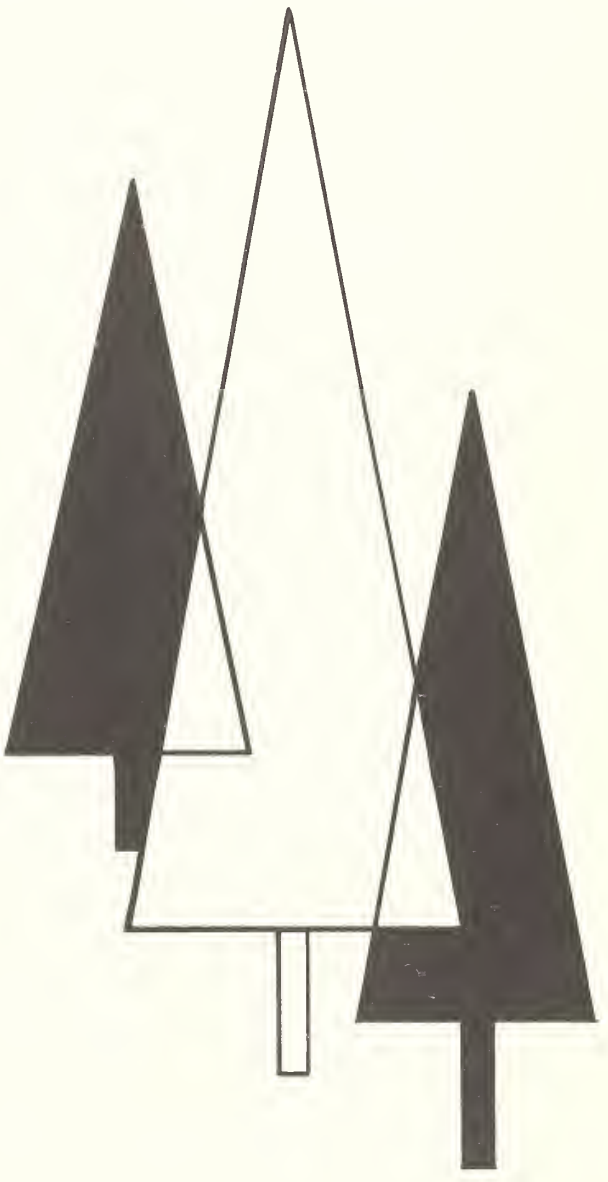
A cooperative study by New Mexico State University and the Rocky Mountain Station concluded that available raw materials could support a number of particleboard plants in New Mexico. The advantages and disadvantages of 17 different locations were explored. Conditions are most favorable in north-central New Mexico, but other parts of the State also offer possibilities.

Annual demand for particleboard in the Southwest is expected to double by 1975 when it will exceed 100 million square feet (¾-inch basis). Present supplies come primarily from Oregon and California mills. New Mexico plants would have a considerable freight advantage in the Southwest over West Coast and Southern plants, and should be able to capture a significant share of local markets at a comparable delivered price.



A giant particle and adhesive blender at a new particleboard plant in the Southwest.

COMMON AND SCIENTIFIC NAMES OF ANIMALS AND PLANTS MENTIONED



ANIMALS

Birds

Bluebird, mountain	*Sialia currucoides* (Bechstein)
Chickadee, mountain	*Parus gambeli* Ridgway
Flycatcher, olive-sided	*Nuttallornis borealis* (Swainson)
Grouse, sage	*Centrocercus urophasianus* (Bonaparte)
Grouse, sharp-tailed	*Pediocetes phasianellus jamesi* Lincoln
Junco, gray-headed	*Junco caniceps* (Woodhouse)
Sparrow, Brewer's	*Spizella breweri* (Cassin)
Turkey, Merriam's	*Meleagris gallapavo merriami* Nelson
Woodpecker, downy	*Dendrocopos pubescens* (Linnaeus)
Woodpecker, hairy	*Dendrocopos villosus* (Linnaeus)
Woodpecker, northern three-toed	*Picoides tridactylus* (Linnaeus)

Mammals

Antelope	*Antilocapra americana* (Ord)
Badger	*Taxidea taxus* (Schreber)
Deer, mule (desert)	*Odocoileus hemionus crooki* (Mearns)
Deer, mule (Rocky Mountain)	*Odocoileus hemionus hemionus* (Rafinesque)
Deer, white-tailed (Coues)	*Odocoileus virginianus couesi* (Coues & Yarrow)
Deer, white-tailed (South Dakota)	*Odocoileus virginianus dacotensis* Goldman & Kellogg
Elk	*Cervus canadensis canadensis* (Erxleben) Reynolds
Gopher, northern pocket	*Thomomys talpoides* (Richardson)
Jackrabbit, white-tailed	*Lepus townsendi* Bachman
Mouse, white-footed	*Peromyscus maniculatus* (Wagner)
Squirrel, Abert	*Sciurus aberti* Woodhouse

PLANTS

Forbs

Alfalfa	*Medicago sativa* L.
Avens, golden	*Geum rossii* (R. Br.) Ser.
Bistort, American	*Polygonum bistortoides* Pursh
Burroweed	*Haplopappus tenuisectus* (Greene) Blake
Clover, dwarf	*Trifolium nanum* Torr.
Fleabane, alpine	*Erigeron simplex* Greene
Sneezeweed, orange	*Helenium hoopesii* A. Gray
Strawberry, false	*Sibbaldia procumbens* L.

Grasses and Grasslike Plants

Bentgrass	*Agrostis castellana* Boiss. & Reut.
Bluegrass, Kentucky	*Poa pratensis* L.
Bluegrass, Sherman big	*Poa ampla* Merr.
Brome, smooth	*Bromus inermis* Leyss.
Buffelgrass	*Cenchrus ciliaris* L.
Cottontop, Arizona	*Trichachne californica* (Benth.) Chase
Fescue, meadow	*Festuca elatior* L.
Fescue, red	*Festuca rubra* L.
Fescue, sheep	*Festuca ovina* L.
Fescue, Thurber	*Festuca thurberi* Vasey
Hairgrass, tufted	*Deschampsia caespitosa* (L.) Beauv.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Lovegrass, weeping	*Eragrostis curvula* (Schrad.) Nees
Spikefescue	*Hesperochloa kingii* (S. Wats.) Rydb.
Timothy	*Phleum* spp.

Shrubs and Trees

Alder, Arizona	*Alnus oblongifolia* Torr.
Ash, green	*Fraxinus pennsylvanica* Marsh.
Aspen, quaking	*Populus tremuloides* Michx.
Bearberry	*Arctostaphylos uva-ursi* (L.) Spreng.
Bitterbrush	*Purshia tridentata* (Pursh) DC.
Chokecherry	*Prunus virginiana* L.
Cottonwood, eastern	*Populus deltoides* Bartr.
Cottonwood, plains	*Populus sargentii* Dode
Douglas-fir, Inland	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Fir, white	*Abies concolor* (Gord. & Glend.) Lindl.
Juniper, alligator	*Juniperus deppeana* Steud.
Juniper, one-seed	*Juniperus monosperma* (Engelm.) Sarg.
Juniper, Rocky Mountain	*Juniperus scopulorum* Sarg.
Juniper, Utah	*Juniperus osteosperma* (Torr.) Little
Larch, Japanese	*Larix leptolepis* Sieb & Zucc.
Maple, bigtooth	*Acer grandidentatum* Nutt.
Mesquite, velvet	*Prosopis velutina* L. Benson
Mountainmahogany, birchleaf	*Cercocarpus betuloides* Nutt.
Oak, Gambel	*Quercus gambelii* Nutt.
Oak, northern red	*Quercus rubra* L.
Oak, shrub live	*Quercus turbinella* Greene
Pine, Austrian	*Pinus nigra* Arnold
Pine, eastern white	*Pinus strobus* L.
Pine, jack	*Pinus banksiana* Lamb.
Pine, limber	*Pinus flexilis* James
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, ponderosa	*Pinus ponderosa* Lawson
Pine, red	*Pinus resinosa* Ait.
Pine, Scots	*Pinus sylvestris* L.
Poplar, Eurasian black	*Populus nigra* L.
Redcedar, eastern	*Juniperus virginiana* L.
Rose, Arkansas	*Rosa arkansana* Porter
Rose, Woods	*Rosa woodsii* Lindl.
Sagebrush, alkali	*Artemisia longiloba* (Osterhout) Beetle
Sagebrush, big	*Artemisia tridentata* Nutt.
Saltbush, fourwing	*Atriplex canescens* (Pursh) Nutt.
Snowberry, western	*Symphoricarpos occidentalis* Hook.
Spruce, blue	*Picea pungens* Engelm.
Spruce, Engelmann	*Picea engelmannii* Parry
Tamarisk, five-stamen	*Tamarix pentandra* Pall.
Tamarisk, smallflower	*Tamarix parviflora* DC.
Winterfat, common	*Eurotia lanata* (Pursh) Moq.

This publication reports research involving pesticides and herbicides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.
CAUTION: Pesticides and herbicides can be injurious to humans, domestic animals, desirable plants, honeybees and other pollinating insects, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides and herbicides selectively and carefully. Follow recommended practices for the disposal of surplus materials and containers.

Trade names and company names are used for the benefit of the reader and do not imply endorsement or preferential treatment by the U. S. Department of Agriculture.

About The Forest Service. . . . .

As our Nation grows, people expect and need more from their forests—more wood; more water, fish and wildlife; more recreation and natural beauty; more special forest products and forage. The Forest Service of the U. S. Department of Agriculture helps to fulfill these expectations and needs through three major activities:

- Conducting forest and range research at over 75 locations ranging from Puerto Rico to Alaska to Hawaii.
- Participating with all State forestry agencies in cooperative programs to protect, improve, and wisely use our Country's 395 million acres of State, local, and private forest lands.
- Managing and protecting the 187-million acre National Forest System.

The Forest Service does this by encouraging use of the new knowledge that research scientists develop; by setting an example in managing, under sustained yield, the National Forests and Grasslands for multiple use purposes; and by cooperating with all States and with private citizens in their efforts to achieve better management, protection, and use of forest resources.

Traditionally, Forest Service people have been active members of the communities and towns in which they live and work. They strive to secure for all, continuous benefits from the Country's forest resources.

For more than 60 years, the Forest Service has been serving the Nation as a leading natural resource conservation agency.